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The "Houille Blanche" Congress in France.

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Introductory.

THE picturesque title of "Houille Blanche" which was originated about twenty years ago by the well-known pioneer of the utilisation of power generated from water-falls in France, Mr. Aristide Berges, was applied in the first instance solely to the reserve of energy available in the mountain snows and ice-fields.

This signification has latterly been extended to include the utilisation of force from all mountainous falls and torrential rivers, and the development of this idea, as well as the practice, has been gradually assuming definite shape, as witness the number of hydro-electric works now installed. The owners and promoters of these latter were compelled, by various reasons, chiefly owing to the crisis in the trade of calcium carbide and reactional legislation, to constitute themselves into a syndicate, and in order better to discuss the various technical difficulties which the situation presented, the Congrès de la Houille Blanche was inaugurated, at which the most prominent technical and legislative ability was represented.

Over five hundred men of all qualifications attended the meetings, which were fittingly held in the interesting district of our present description, these delegates being collected from all parts of France, and even from abroad.

From September 7th to September 18th, 1902, numerous conventions and meetings were held, and visits were made to the typical works and factories of the district.

The meetings naturally divided themselves into two kinds, following, in broad lines, the questions raised thereat, which comprised both economical and technical aspects of the matter.

In the consideration of the economical questions at meetings specially convened therefor two aspects were dealt with:

(1) The State considered as the owner of the hydraulic energy, and giving concession for its use, under certain conditions, to individuals or societies.

(2) The falls and source of energy considered as the individual property of the proprietors of the district in which the same is found.

The various arguments advanced, for and against, cannot be here discussed; but it is sufficient to add that the great majority of the congressmen oppose the state ownership or intervention, though at the same time considering the second system somewhat defective, owing to the

power of one unwilling proprietor to veto any scheme partly affecting his interests. The second resolution was, however, agreed upon, leaving to future decision modifications which will evolve from its application.

In the technical sectional meetings, several papers have been read dealing with river flow, regulation, variations of level, utilisation, and measurements, not omitting the transmission of power, and the applications in electro-chemistry.

The more strictly technical part of the subject was investigated by a number of eminent engineers. The transportation of power received particular attention, especially concerning certain particular systems; that is, high tensions at continuous and three-phase currents, and even with reference to their actual use in stations, as will be hereafter described. With reference to these should be quoted the names of MM. Thury and Boissonnas.

Having regard to the electrical characters of the plants M. Picou strongly opposed the defective practice of building alternators for direct generation of very high tensions, for example, 26,000 volts, which is used in one of the installations visited.

The electro-chemical industry was represented by M. Gall, whose remarks concerned chiefly the economic side of the question. He gave his conclusions regarding the actual status of the branch of industry which he represented, especially in connection with the calcium carbide trade, which has undergone such a crisis within recent years. It would appear that the production of aluminium has been worked in connection with the former trade, and also that the production of chlorine and chlorides is allied to the same, being only limited by the demand for these latter chemicals. Interesting details were also given regarding the study made in France in late years in the production of ferro-chrome, ferro-silicium, ferro-nickel, etc., for disposal to iron foundries, together with products forming these latter alloys.

As regards the hydraulic questions dwelt upon, most papers read related solely to certain specific installations, and will be best treated in descriptions of such plants. In this class may be included regulation of streams by reservoirs, speed governing of turbines, investigations of conditions of flow from alpine districts, etc.

It is proposed to deal with but one of the above points of interest, which being of general character, applied to most hydraulic and electrical installations. This is in respect to the direct utilisation of mountain streams deprived of reservoirs, which form the majority, and are characteristic of this wild region. By courtesy of the author of the Paper, we are enabled to give much of his data and information which will help in the general considerations of the subject.

The title of the paper referred to is the "Utilisation of a Torrential Fall," but it will be seen that we have enlarged the points of view dealt with by the use of information derived from visits made, and other sources.

Characteristics of a Torrential River.

The output of torrents is tediously variable, depending not only on the season, but also on the amount of rain or snow falling within a given time, and the quality of the basin or watershed. Snowfields and glaciers form reserves of long duration, but the available energy is very variable, the streams and falls being very rapid, and not of a lasting character. The woods and forests form, so to speak, a temporary reserve by withholding the quick descent of the water to the watercourses.

Taking, for example, the upper Rhone in the Valais. In time of high water the upper Rhone may reach as much as 600 m. 3 for one or two days. In ordinary years, however, the maximum is below 300 m. 3 for the same time.

The average, during 19 days, out of 365 days, is 21-30 m.3. The average, during 39 days out of 365 days is 30-40 m.3.

This will be seen clearly from the accompanying diagram, which is characteristic of most of the streams of the region. Fig. 1 represents the variations of flow of the upper Rhone in the

Vallais. This diagram thus refers to the largest river in the region. Similar diagrams will be given in due course in the respective descriptions hereafter.

In the above or similar cases, it would be very unfortunate to count on several hundreds of cubic metres, and to thus fix the power of the machines and the receipts from subscribers.

Electro-chemical employment of energy, however, allows the use of irregular power.

In certain cases, however, which will be dealt with later, some lakes, forming natural reservoirs, allow, when their capacity amounts to at least one-fourth of the total annual flow of the stream, the complete regularisation of the flow, and make possible a regular daily flow.

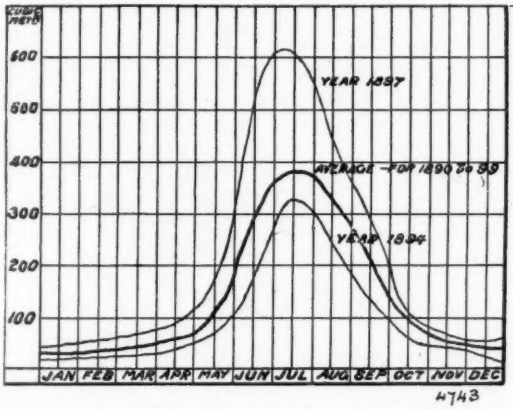


FIG. 1.—DIAGRAM SHOWING THE AVERAGE MONTHLY VOLUMES OF FLOW OF THE UPPER RHONE RIVER AT SAINT-MAURICE (1890 TO 1899).

In other cases it has been possible to install artificial reservoirs, but generally of too small a capacity for allowing a complete regularisation of the flow The best that can be done in most cases, is to store an amount equal to the daily flow, in order to have sufficient water for the maximum.

Lastly, in other cases, and more especially when a public service of lighting and traction, for instance, is obligatory, it is necessary to have reserve steam plant.

On the other hand the electro-chemical industry is well adapted and can much more easily accommodate itself to the irregularity of flow. Among these applications, foremost was the calcium carbide production, but it has been discovered that acetylene consumption was far below the expectations, and the expected development has not taken place.

The main difficulties applying to the nature of torrential rivers will now be examined, together with the best practicable dispositions for remedying the trouble.

During very high floods the rivers carry immense quantities of floating and suspended matters, leaves and branches of trees, sand and pebbles; and great care must necessarily be taken for protecting the plant, conduits, and especially the turbine distributors therefrom.

Pebbles and floating matters have to be feared mostly, as they may cause obstruction in conduits, and mainly in turbine distributors, thus causing a complete stop of the plant. This does not take account

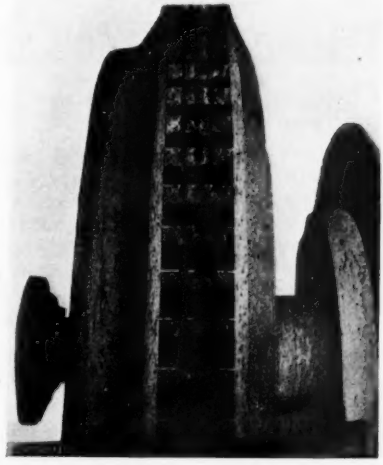
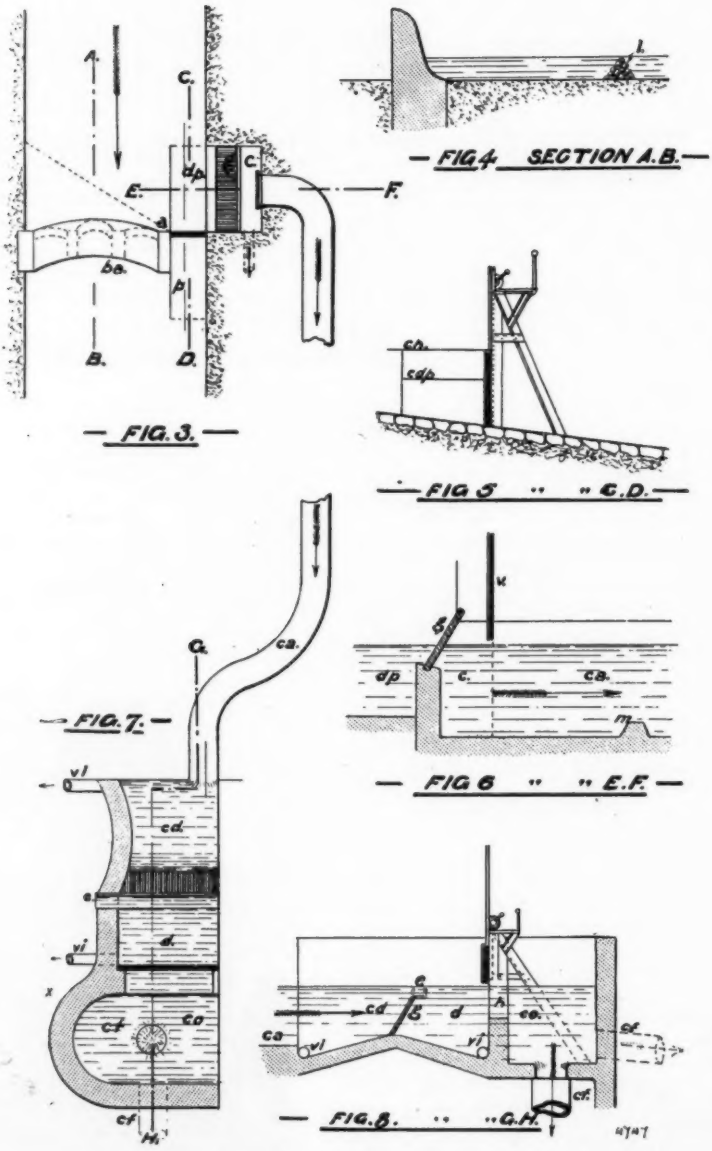


FIG. 2.—SHOWING HOW A TURBINE BECOMES WORN BY THE ACTION OF SUSPENDED MATTER IN THE WATER.



FIGS. 3-8.—SHOWING METHODS FOR DISPOSING OF FLOATING MATTERS AND GRAVEL.

of the sand of an exceedingly fine nature, which is in suspension in the water and is impossible to get rid of, and which causes rapid deterioration and wearing of the turbine vanes and distributors. Arrangements are made, however, for allowing a rapid replacement of the wearing parts, as it has been shown by many experiments that comparatively pure water, such as obtained from still lakes, causes a rapid wear owing to the high pressure.

Fig. 2 shows a turbine thus worn out after a few months operation at a pressure of 130 m. of pure water.

Regarding the best means adopted for disposing of the floating matters and gravel, our readers will find them represented in Figs. 3 to 8.

Figs. 3, 4, 5, and 6 refer to water intake devices. The dam is a masonry construction of curved form, the convexity of which is facing up-stream, for sake of resistance to water current.

Fig. 4 shows the dam profile arranged for the overflow fall of water, and the pilings, sometimes added down stream for avoiding the baring of the river bed by the water.

On the intake side of the dam is provided an outlet *p* for discharging the deposits.

The intake is made by a longitudinal overflow *d p*, provided with a grating *g*, intended to keep out the floating matters. These are removed by the river flow. It is highly important to take surface water by overflow, in view of having comparatively clean water.

The intake vane *v* regulates the quantity of water. Directly after the intake is seen the intake chamber *c*, in which water has a low speed, and thus deposits a deal of the suspended matters, which can be discharged by the bottom opening *v i*. These figures are self-explanatory, and do not require much commenting on.

The decanting chamber *c* is followed by the canal *c a*, the lower end of which is arranged as seen in Figs. 7 and 8.

The following rules apply to the canal construction itself:—

Protection from avalanches or rock falls is essential, these occurrences being frequent in this country. For this reason the canal is removed from the rocky surroundings, and is made of armoured cement, supported by special bed of concrete; or else is made in a tunnel in the rock itself. In the latter case the tunnel must be suitably

FIG. 9.—VIEW OF A WATER CONDUIT PROTECTED BY A PREZOMETRIC TUBE.

lined with hydraulic cement, even in the case of compact rock. Neglect of this precaution has often led to great damage.

The charging chamber overhangs the station, more or less distant, and must be very securely and strongly constructed. Figs. 7 and 8 represent the main parts into which the chamber is usually divided.

(1) *c d* and *d* are decanting chambers, divided by a grating *g*, on the top of which is a leaf-catcher *e* inclined on the river side, where the water current carries away the leaves. On the same side is a regulating overflow valve discharging to the river the water not used by the station.

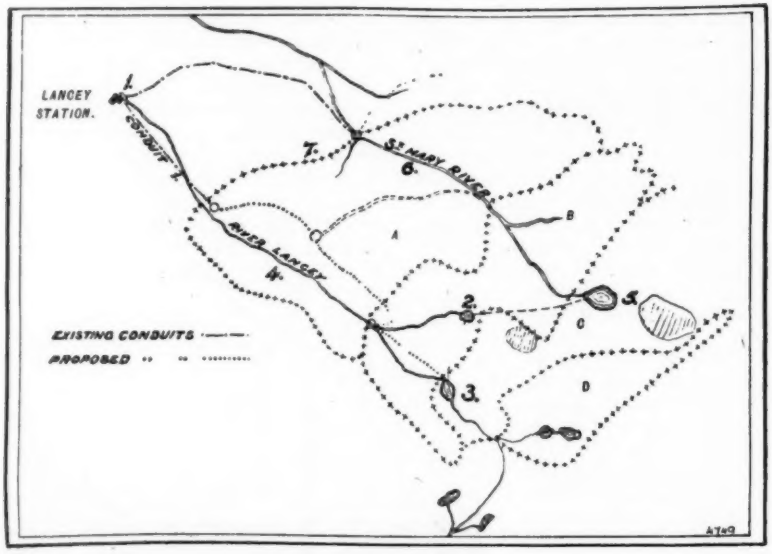


FIG. 10.—MAP OF THE LANCEY DISTRICT.

(2) Second chamber, *co*, divided from the preceding chamber by an overflow, *x*, is intended to charge the conduits feeding the station. The admission valve is mounted on the chamber, and not on the conduit, in order to allow communication from the conduit to the open air; thus, in case of sudden emptying of the conduit, there is no vacuum inside, and therefore no flattening of the conduit by reason of atmospheric pressure — an incident which has been experienced in Chedde station. The same reason affords an explanation of the use of open-air tubes, which are often used on the length of the conduits, of which Fig. 9 offers a fair illustration.

Protected from the fall of rocks, like the canal itself, the forced conduit is made of soft boiler-steel sheets assembled by rivets. The thickness is so calculated that the strain does not exceed 4 to 6 kilogrammes per mm.2. For smaller sizes of conduits, however, the steel sheets are fitted and soldered.

The sections of the conduit are connected by means of short overlapping joints, riveted; or by means of flanges, with the interposition of asbestos and copper or lead joints.

When of a large diameter the conduit should be supported at points up to half its height, for avoiding the deformation when suddenly filled up, and especially when inclined at a small slope.

When not underground it is necessary to provide for expansion. Expansion joints are not recommended, and are replaced with advantage by bends.

The effect of frost in winter would be the breakage of the conduit in case of the stop of the water-flow. Therefore the flow is maintained, or the conduit is buried in soft earth to a depth of one or two metres, which gives sufficient safeguard.

The Itinerary of the Congress.

First and most interesting of the watersheds visited by the Congressmen is the Bassin de Lancey, which offers an example of an installation differing in many

respects from the one treated above in the general considerations.

Lancey Waterfalls.

In existence.—

200 m.	head –	500 litres.
547 m.	,,	547 ,,
474 m.	,,	800 ,,
514 m.	,,	800 ,,

Projected.—1,700 m. fall, by means of three stations in series.

The existing installations compose but a small part of the projects outlined below, but they furnish power to a paper factory, to tramway and lighting plants, which will be reviewed after a rapid investigation of the Bassin de Lancey.

I. *Bassin de Lancey* (Fig. 10).—The generating station in operation has been erected by Mr. Berges at Lancey, and has an exceptional situation, being situated at a height of 250 metres above the sea level, and is overshadowed by the precipitous and massive Belledone mountain, nearly at the summit of which are several lakes —namely, the Lake of the "Grand Site," Lake Crozet, serving the watershed of Lancey, and Lake Blanc, forming the St. Mury River in a neighbouring valley, the flow of which has been so arranged at the neck as to feed the Lancey plant by means of conduits, marked *II* on the plan.

From a hydrometrical point of view the basin common to the Lancey and Mury Rivers may be divided into three parts—marked *A B C*—and separated by + + + on the plan:—

(*A*) Between the levels of 760 and 1,260 metres, with a superficial area of 15,800,000 square metres.

(*B*) Between levels 1,260 and 2,000 metres, with an area of 400,000 square metres.

(*C*) Above 2,000 metres, with an area of 5,552,000 square metres.

A fourth zone (*D*) feeds the Lake Domenon, which feeds both the Lancey and Domenon Rivers, the latter forming, with the Lancey River, below the town and installation of this name, the River Isère.

By agreement come to, the watershed of the Lancey plant receives one-third of the flow from Lake Domenon, the division being made in *P* in an installation made for this purpose, and designed by M. de la Brosse, then chief engineer at Grenoble.

The basin feeding the lakes at Domenon has an area of 2,634,000 m.2, one-third of which—that is, 880,000 m.2 —feeding rivers in the Lancey watershed, and also St. Mury, so that the resultant area of that part of the common watershed situated above the height of 2,000 metres is about 6,400,000.

Lancey station is now fed by four forced conduits, two starting from the intake at St. Mury, and two from that of Lacombe.

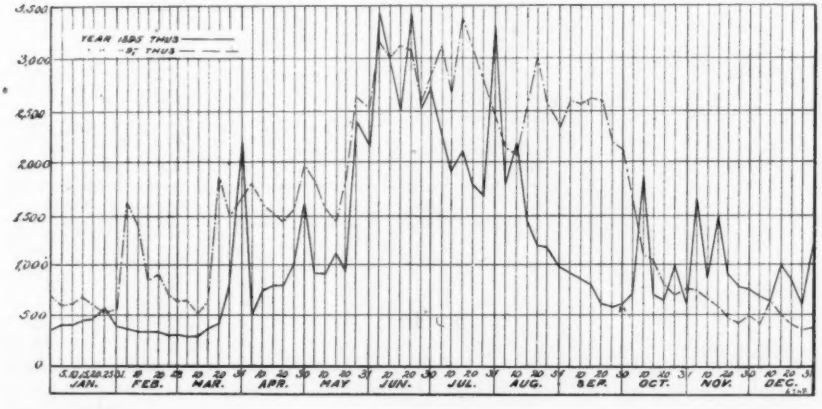


FIG. 11.—CURVES SHOWING THE VOLUME OF WATER OBTAINED IN THE LANCEY WATERSHED FOR THE YEARS 1895, 1897.

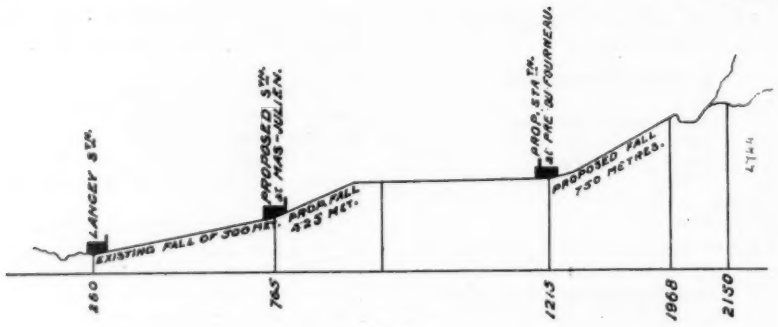


FIG. 12.

Mr. Berges has caused the intake at the above points to be accurately gauged, which was done regularly between 1895 and 1897, before the matter was regulated by agreement, as above stated.

The following table and curves give the average monthly, as well as yearly, flow of water, from which it will be seen that the minimum discharge took place in 1895.

Fig. 11.—The curves give the volume obtained during the years 1895 and 1897, from which it will be seen that the variations are very great.

The table below gives the volumes of water, average and maximum, during four years.

With respect to the total yearly fall of water, it is interesting to investigate the necessary reserve storage capacity—*i.e.* the capacity of reservoirs for regulating the flow. We can, in order to do this, determine from the average flow during certain months the quantity which, in summer, is in excess of this average flow. By totalling these reserves we obtain a sum proportional to the necessary storage. Thus the average flow multiplied by 12 will give similarly a number proportional, in the same conditions, to the yearly volume, and the relation between the capacity of reservoirs and the annual fall of water can be easily ascertained.

The table at foot of page gives the years and months corresponding to excess of water, and the tabulated figures give the excess volume in the corresponding years and months.

	1895	1896	1897
April ...	—	—	159·2
May ...	285·0	—	498·4
June ...	981·7	1,195·92	1,345·5
July ...	830·5	907·32	813·6
Aug. ...	383·5	679·52	458·6
Sept. ...	—	1,112·52	843·6
Oct. ...	—	654·52	—
TOTAL R	2,480·7	4,549·80	4,118·9
Yearly average volume :—			
	1895	1896	1897
A (per month):	1,021·5	1,420·48	1,386·4
Per year:			
12 A = A	12,258·0	17,045·76	16,636·8
Ratio R/A :	0·202	0·266	0·247

Years.	Volumes.			Ratio of Minimum to Maximum volume.		Ratio of Maximum to Average volume.	
	Maximum.	Minimum.	Average.	Average.	Maximum.	Minimum.	Average.
1895	3,420	300	1021·5	0·300	0·088	11·4	3·35
1896	3,800	420	1420·48	·400	·110	9·05	2·71
1897	3.380	380	1386·4	·416	·112	8 89	2·44
1898	3,230	270	1386·4	·416	·084	11·95	2·44

In 1895 the minimum volume was given on 10th March, the maximum volume the 6th June.
,, 1896 ,, ,, ,, 28th Feb., ,, ,, 10th Aug.
,, 1897 ,, ,, ,, 25th Nov., ,, ,, 17th July.
,, 1898 ,, ,, ,, 31st Jan., ,, ,, 25th June.

From this one can conclude that, if the capacity of the reservoir amounts to about one-fourth of the total annual fall of water, it will be possible to store all flow above the average.

From the average volume per second in litres (V) we deduce the yearly volume in m.3 (V) by multiplying V by $0{\cdot}001 \times 365 \times 24 \times 60 = 31{,}536$.

The following are the rainfalls in the Lancey and St. Mury watersheds above the level of 750 m. :

		Volume.
1895.	1,021·5 × 31,536 =	32,214,024m.3 of water.
1896.	1,420·48 × 31,536 =	44,796,626m.3 of water.
1897.	1,386·4 × 31,536 =	43,721,510m.3 of water.

The fall of water in 1896 therefore amounts to 1·39 times more than in 1895, and 1·36 times that of 1897.

We must consider that there are three parts to the basin. The first, as above stated, consists in that part between the levels of 760 m. and 1,260 m. The second, that comprised between the levels of 1,260 m. and 2,000 m. The third part is that above the level of 2,000 m.

The quantity of rain and snow which forms the flow increases with the altitude, and Mr. Berges, agreeing with the opinion of the best meteorologists, estimates that the flow of water from each zone is in the following ratio: 5, 7, 11, the latter figure applying to the highest region.

The relative volumes of rain for the three zones are deduced from the respective areas of these zones, as recorded in the table on p. 482.

The fall of water (as snow or rain) in 1895 on the zone No. 3, above 2,000 m. from sea level, being 10,533,986 m.,

FIG. 13.—GENERAL VIEW OF LANCEY WITH WATER JET. A PRESSURE CONDUIT IS SEEN IN THE BACKGROUND.

and the surface of this zone being 6,400,000 m.2, the depth of water per square metre is therefore 1·65 m. That of the zone between 1, 260 m. and 2,000 m. is

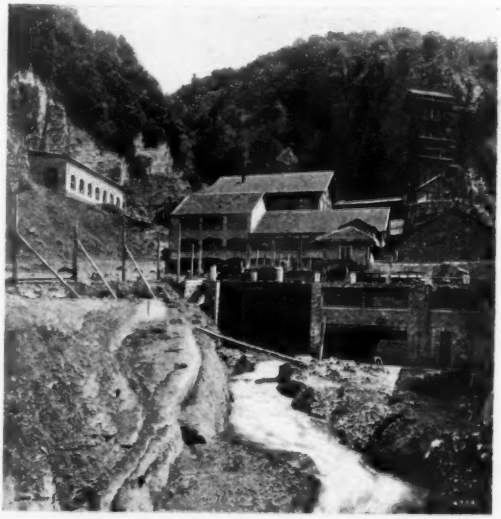


FIG. 14.—GENERAL VIEW OF LANCEY INSTALLATION FROM DOWN STREAM.

$$\frac{1{\cdot}65 \times 7}{11} = 1{\cdot}05 \text{ m.};$$

the lower zone $\frac{1{\cdot}65 \times 5}{11} = 0{\cdot}75$. We have thus the following table:

	1st zone.	2nd zone.	3rd zone.
In 1895	0·75	1·05	1·65
1896 (1·39)	1·04	1·46	2·29
1897 (1·36)	1·02	1·43	2·24

The minimum flow was, in 1895, thus proportional to the following respective figures:

1st zone	..	...	110 litres.
2nd ,,	...	...	92 ,,
3nd ,,	...	...	98 ,,

With no regulation of the superior lakes the power at Lancey station in 1895 was $V \times H = 300 \times 500 = 150{,}000$ kg.m. Assuming a turbine efficiency of 75 per cent., dividing the kg.-metre by 100 gives the mechanical horse-power on the shaft of the turbines, thus $P =$ therefore 1,500 h.p.

With regulation of the water-flow falling from the 3rd zone, through the intermediate

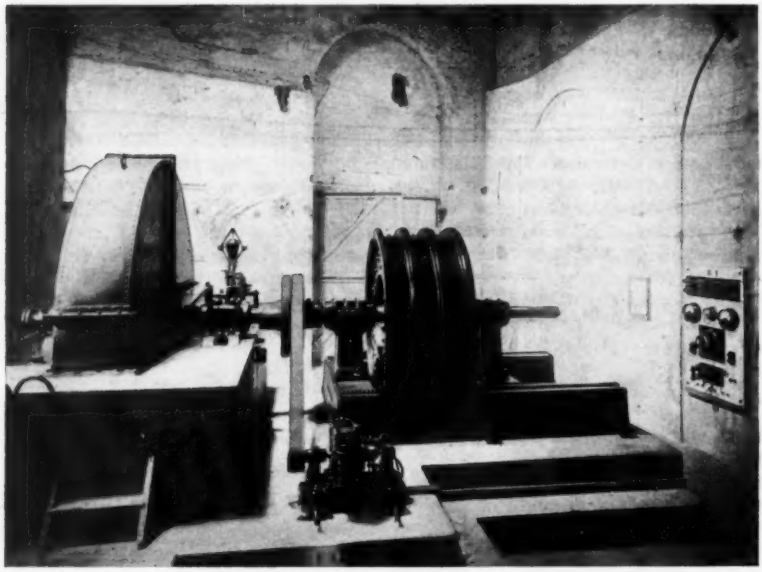


FIG. 15.—INSIDE VIEW OF LANCEY LIGHTING STATION.

	Relative Values of Special Volumes.	m2 Relative Areas m2 × 105	Product.	Proportion of Volume of Rain.
1. Between 760 and 1,260	5	158	790	0·367 or 367%
2. ,, 1,260 and 2,000	7	94	658	0·306 ,,
3. Above 2,000	11	64	704	0·327 ,,
			2,152	1,000

m^2 = sq. m.

lakes, the annual flow can be taken as 10,500,000 m.3 per year, which corresponds to $\frac{10,500,000}{31,536} = 333$ litres per sec., regular flow during the whole year. This will give, then, as minimum water:

Flow from 1st zone ...	...	110 litres.
,, 2nd ,, ...	...	92 ,,
,, 3rd ,, ...	...	333 ,,
Total ...	...	535 litres.

The above will give 2,675 h.p. on the turbine shaft with a fall of 500 metres. Obviously there would be no need to regulate the flow to obtain a steady output, as in the moments of low-water the flow can be augmented by means of the upper reservoir.

Mr. Berges has adopted the following arrangement of reservoirs, which will be completed in the near future. To connect the Lake Blanc and the Lake Grand Site by a tunnel of 1,300 m. to the Crozet lake. (Both these tunnels are already started.) This would give three successive reservoirs regulated by valves. At the present time the Lake Blanc is pierced by a tunnel of 400 m. in length, at a level of 21 m. below its surface, in order to tap the extra 1,100,000 m. thus given. The tunnel of Lake Crozet has also been finished in 1897, and allows the level of the lake to be lowered some 25 m.; and a dam of 3·60 m. in height gives 1,200,000 m.3.

Lake Blanc ...	...	1,100,000 m.3.
Lake Crozet ...	...	1,200,000 ,,
Total	...	2,300,000 m.3.

The above-mentioned dam can be raised above 3·6 m., and each additional metre gives a reserve of 75,000 m. to 80,000 m.3, so that, as we have seen, the reserve in a year of maximum flow should be 0·202 × 10,500,000 = 2,121,000 m.3, which should be sufficient for all needs.

Besides the regulation of the lakes as above, the projects of Mr. Berges include the following (illustrated by profile, Fig. 12):

(1) The building of a station at Pré des Fourneaux, using the waters of the watershed above the height of 2,000 m., with a head of 750 m.

(2) The building of a second station at Mas Julien, receiving the water from Lake Crozet plus the water flowing from the second zone, all collected by conduits without pressure, and led to a reservoir placed at Prelong at the head of fall of 425 m.

(3) The retention of the Lancey station, receiving, as now, all waters from the three zones, with 500 m. head.

Thus the total head of the fall will be 750 + 425 + 500 = 1,675 m., with a minimum annual output of 10,500,000 m^3.

Thus the following k.g.-m., or corresponding ton-metres, for the above three stations give the following figures:

Station.	Ton-Metres.
Fourneaux ...	10,500,000 × 750 = 7,875,000,000
Mas Julien ...	10,500,000 × 425 = 4,462,500,000
Lancey	10,500,000 × 500 = 5,252,000,000
Total ...	17,589,500,000

Now a horse-power-hour on the shaft of the turbines, assuming an efficiency of 75 per cent., represents 60 × 60 × 100 k.g.-m. water power = 360,000 k.g.-m., or 360 ton-metres. Thus the yearly h.p.-hrs. =

$$\frac{17,587,500,000}{360} = 48,854,200 \text{ h.p.-hrs.}$$

The daily h.p.-hrs. =

$$\frac{48,854,200}{365} = 183,800 \text{ h.p.-hrs.}$$

—*i.e.* a power of 5,575 h.p. for a continuous uniform full load output at the stations, or 11,150 h.p. for a 12 hour load per day. To this power will be added the power which could be collected in the two lower stations for the second zone, the output of which is not regulated.

Now, calculating the minimum power of the second zone as: Head of fall 425 + 500 = 925 m. (minimum volume 92 litres,)—that is, 85,180 kg.-m. per second, 851 h.p. on turbine shaft.

At Lancey station the volume of water for the two lower zones, under 500 m. head fall: minimum volume or weight = 110 + 92 = 202 litres or kg.; power = 202 × 500 = 101,000 kg.-m. per second, or 1,010 h.p. Thus we have on turbine shaft, at uniform power, during the whole of the year: 5,575 + 851 + 1,010 = 7,436 h.p. This supposes that the water retained in the higher lakes of the third zone is only 2,121,000 m.3. This would be increased, for instance, by a dam of 15 m.

height, which would augment the amount of water retained of 75,000 m^3 per metre supplementary height, also 75,000 (15 – 3·60) = 855 m^3, thus carrying it from 2,300,000 m^3 to 3,155,000 m^3.

It would therefore be possible to greatly increase the help given by the lower zone at times of low water, and, in large proportions if this were necessary, the power of the plant.

In summer, when the lower zones have a much superior power to that which we have seen as their minimum power, the maximum power of the lower falls would equal 11·4 (851 + 1,010) = 21,615 h.p. The retaining valves or vanes would be closed, so that in winter, when the water is low, the reserve water would make up any deficiency.

For getting this result the power would have to be increased: turbines, first zone, 1,010 h.p.; second zone, 851 h.p.; third zone, 5,575 h.p. For a steady output of 10,000 h.p., turbines of the third zone 8,139 h.p., and increase proportionally the power of the others, in order to have a greater reserve of water in the third zone.

One of the falls in existence at Lancey can be seen from Fig. 13. One of the conduits is open in this figure, and a magnificent water jet is thus shown. The jet is of such a force that the Congressmen were unable, after repeated efforts, to cut the jet near the conduit by means of a sword.

Fig. 14 shows the whole of the installation from the tail-race side on the right, the paper factory and lighting station appearing on the left and the tramway installation on a rocky bank.

I. *The Berges Paper Factory*, above-mentioned, is used by the proprietor in the production of paper (10,000 tons per annum), wood-pulp (3,500 tons), and cellulose (4,000 tons), and is run entirely by mechanical means from the waterfall. Twelve turbines are installed of an aggregate power of 4,000 h.p. to 5,000 h.p.

The plant was originated in 1868, when the first conduit was laid to bring water with a head of 200 m. from the Combe torrent. The volume of water available was 500 litres per second. This plant has been very successful, and no difficulties whatsoever were encountered from the use of the high head of water.

The turbines of 4,000 h.p. to 5,000 h.p., as above-mentioned, are moved by the action of water jets of 20 mm. in diameter at the periphery of the wheel. Only four jets are needed for a turbine of 600 h.p. The turbine wheel is of large diameter—some 4 m.—for the 600-h.p. type, and the thickness of the wheel is but 5 c.m.

A continuous-current generating set is used in connection with the paper mills for production of hypochloride, used for bleaching the pulp.

II. *The Lighting Station.*—A radius of 15 km. from Lancey, in the Grésivaudan valley, is served with energy from the lighting station. There is nothing of great moment in this station, the same mechanical machinery being employed as in the paper factory. Two single-phase generators are installed, feeding the high tension line with the intermediary of step-up transformers (fig. 15). The peculiarity of these transformers is their paraffine insulation, their windings and cores being dipped in this material.

The line voltage is 10,000 volts, the frequency is 50 cycles. Great economy was observed in the line construction, the total length of the transmission being some 50 km.

The line transformers, that is, the transformers installed on the line itself, stepping down the voltage to 120, are also insulated by means of paraffine.

Electric lighting is employed very generally, owing to its cheapness, and even cottages are not without the glow lamp. The charges for lighting are the following: 16 c.p. lamp, per year, 25 frs.; 10 c.p. lamp, per year, 15 frs.; 5 c.p. lamp, per year, 10 frs. This gives a total of 55 frs. for 35 c.p., an average of 1·60 frs. per candle year. The electric lighting system, as will be seen from the above, is a very popular one in the district, a fact that the promoters do their best to foster, by means of popular charges to customers.

Electric Tramway from Grenoble to Chapareillan.

The erection of this line presented a

very interesting problem, by reason of the following:

(1) Great length of line.

(2) Great height of fall, 500 m., which, issuing from the icefields, presents the very great advantage of producing a motive force varying as the requirements of the tramway, that is, giving the maximum in summer, and the minimum in winter.

(3) The great distance of the station from the nearest point on the line, which amounts to about 3 km.

(4) Great irregularity of the profile.

(5) Lastly, the use of heavy trains for passengers or goods, consisting of three carriages.

The above conditions cause the character of the line to approach nearer to a railway than to a tramway service.

To the long run service is added a suburban service with a greater frequency of trains, running each half hour in both directions. Selection was therefore made of the three-wire system of distributing continuous current, the neutral conductor being the track rails, which system offers the following advantages:—

It allows the concentration of all the generating machinery into one station, and avoids the establishment of sub-stations, from which results a reduction of the labour charge, and of spare material for the installation, and also the centralisation of exploitation records, as well as simplification of inspection. To this is added an economy in line conductor copper, and a notable reduction in rail-bond connections.

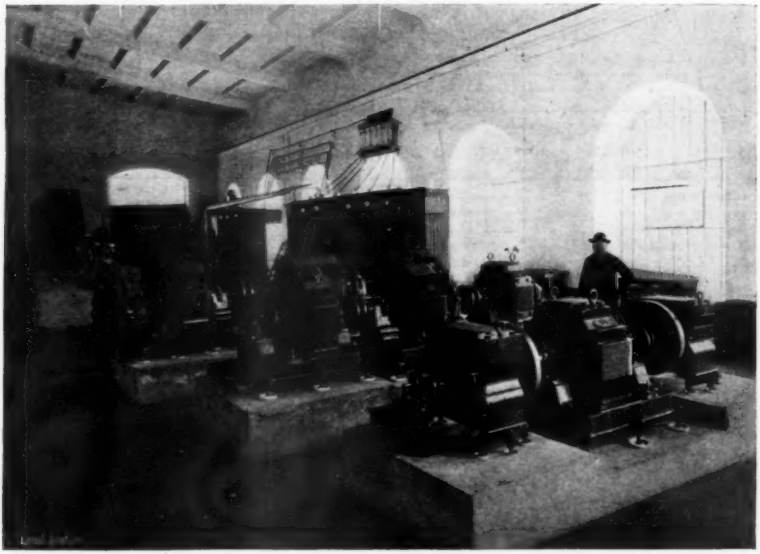


FIG. 16.—INTERIOR VIEW OF LANCEY TRAMWAY GENERATING STATION.

As far as we know, this distribution system, already made use of in various lighting and power transmission installations, has never before been applied to an extended line of tramways, such as that from Grenoble to Chapareillan. Its use, from the obtained results of operation, shows that the system offers an advantageous solution of the problem.

Generating Station.—The generating

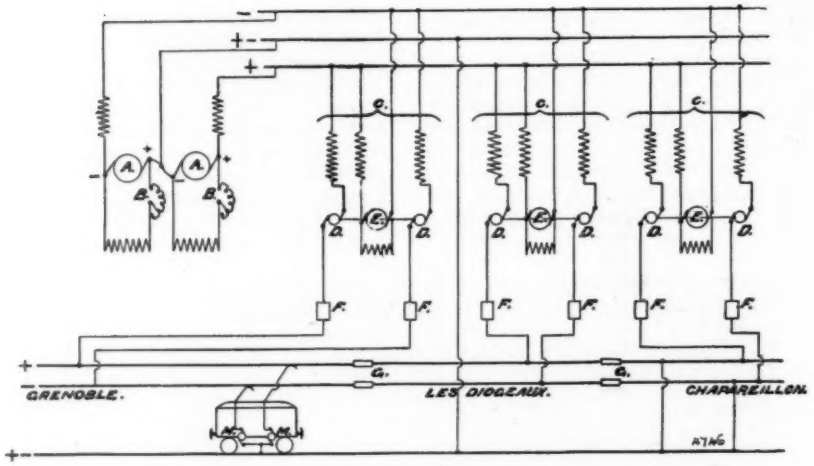


FIG. 17.—GRENOBLE–CHAPAREILLAN TRAMWAYS: DIAGRAM OF CONNECTIONS.

A. Compound-wound Generator. *B*. Automatic Field Rheostat. *C*. Booster Sets. *D*. Series Booster.
E. Compound-wound Booster Motor. *F*. Overload Circuit-breaker. *G*. Section Insulator. *M*. Railway Motors

station uses a fall of 500 m. situated on the flank of a mountain, on which is situated the generating station on a small peaked rock at the entrance of La Combe de Lancey, a village about 15 km. distant from Grenoble, in the direction of Chapareillan. The water is brought to the station by a steel sheet conduit of 10 mm. thickness, under a pressure of 45 atmospheres, with a diameter of 30 cm., ending in a general collector, which distributes equally water power to the "Stn. d'Eclairage de la Vallée du Grésivaudan" cited above. This conduit forms a collector of 40 cm. diameter at its lower end.

From the collector, three conduits lead off to feed the turbines. A fourth tube has been provided in view of the ultimate installation of a fourth turbine. An inside view of the station is given in Fig. 16, and a view of connections is shown in Fig. 17.

Turbines.—The station includes three centrifugal turbines with horizontal axis and cast-iron vanes. The diameter of these turbines is 3 m. and the weight of the wheel is 3 tons. The power of each is 375 h.p., and runs at a speed of 325 revolutions per minute. The water is led from the collector to the turbines by means of a valve-cock with a servo-motor.

The admission of water into the turbines is made by means of oscillating tongues, varying the opening of the bronze nozzles. Centrifugal regulators control the three turbines, two of which are always in operation. The regulators are centrifugal force and servo-motor by a double ratchet and catch system.

Dynamo-generators. — Each turbine is directly coupled by means of a Raffard coupling to continuous current generators. Each generator has six poles, and can give an output of 417 amp. at a potential difference of 600 volts. The field winding is compound excited. The shunt winding includes a rheostat controlled by an automatic regulator which maintains the constant difference of potential at the bus-bars of the switchboard.

Both generators in service are series coupled with neutral wire, connecting their common point to the neutral bus-bars of the switchboard, the outside poles connected to the outside bus-bars of the same, giving 600 volts difference of potential between the latter, and 1,200 volts between the outside wires.

The distributing switchboard of the generators includes apparatus generally employed in traction installations, together

with additional material necessitated by the series operating of the two generators. From the outside bus-bars of the switchboard three feeder wires lead to the overhead line, ending at three feeding points placed where the loss of current, *i.e.*, the consumption of current, is the highest. A seventh wire connects from the neutral bars to the rails, and its cross-section area is 125 mm.2, which is much smaller than the total area of the three feeders. This wire is in fact only, in normal operation, an equilibrium wire, and serves as a return in case there be but one motor in operation on the line.

The following are the extremities of the feeders and their drop in volts: Grenoble, 250 volts; Les Drogeaux, 150 volts; Chapareillan, 400 volts. For the automatic compensation of the drop in the line, each feeder is automatically boosted by a booster set composed of a motor and two generators, boosting the line up to the necessary tension. The motors of these boosters are fed from the outside wires of the switchboard, that is, at 1,200 volts, derived from the two principal generators. These motors are compound wound, which permits a very constant speed, whatever work they are called upon to fulfil.

The booster generators are direct-coupled to booster motors by means of a Raffard elastic coupling. The motors are also run therefore at a constant speed. The generators are series wound, and the amount of the boost is therefore a function of the current they carry, the field varying in proportion to this current between limits. The difference of potential between the two line wires is thus rendered effectively constant.

As seen from the drawing, the two generators of the boosting set are connected to the line similarly to the two motors of a car on the line. They would tend to revolve as motors in the reverse direction, if their motors broke down for any reason, and not only would their speed increase, but, by reason of their series winding, it would tend to accelerate dangerously. There is therefore a ratchet and catch at end of shaft, in order to provide for emergencies. If there happens to be a reversal of rotation, the catch engages a switch which short circuits the armature of the generators. Thus the fields alone have current, and no torque is produced.

The feeders are connected to the bus-bars through the second distribution switchboard, called booster switchboard. This switchboard carries all the measuring instruments, safety devices and control necessary for the good operation of the installation. Among other safety appliances may be mentioned automatic circuit-breakers placed on the feeders to protect the booster generators against abnormal outputs or short circuits of an accidental nature. Atmospheric discharges are, of course, protected against by means of lightning arresters.

Line.—The line leaves the Lancey station, and crosses the railroad tracks of Grenoble-Chambéry on a gangway specially constructed, and crosses the river Isère, which at this place has a width of about 125 m. It is composed of six copper conductors, with a section varying from 125 mm.2 to 65 mm.2, and the neutral cable has a section of 125 mm.2.

A telephone line, connecting all the stations and dépôts and the Lancey

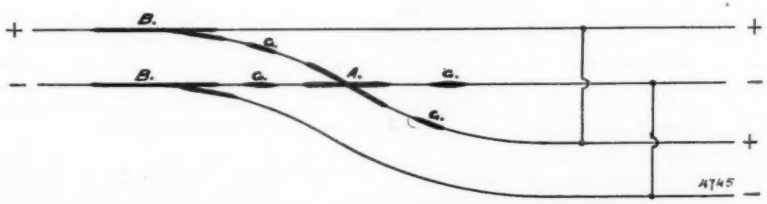


FIG. 18.—GRENOBLE-CHAPAREILLAN TRAMWAYS: OVERHEAD CROSSING ARRANGEMENT.

station, follows the same course. All the conductors are supported by porcelain insulators, with two petticoats, fixed on metallic poles of the André and Joya system.

Track.—The track, of a length of 43 km., including the sidings at Grenoble station to the P.L.M. railway station, runs along the Grésivaudan valley, on the right bank of the Isère. The suburban district is formed of Vignole rails, 25 kilos to the metre, and the part within the city boundaries is formed of Broca rail, of 40 kilos to the metre. Each track is electrically bonded.

Overhead Trolley Line.—The overhead line is formed by hard-drawn copper wires of 9 mm. diameter, distant 700 mm. from one another. They receive current from the feeder switchboard outside wires, and, in consequence, the difference of potential between wires is 1,200 volts.

The line is supported by either metallic poles with brackets of the Joya system, or by cross-wires suspended between side poles or wall fixtures. In crossings, the overhead line is formed of four wires, and even more are requisite in stations and important places. These crossings have necessitated a special arrangement as shown in Fig. 18.

Rolling Stock.—The rolling stock includes motor-cars and trailers, closed in winter and open in summer. They were built by the "Cie. Française de Matériel de Chemins de Fer," at Ivry. The motor-cars are two-axle type, the bodies contain 48 1st and 2nd class seats, and permit ten standing places at the front and rear platforms. They are equipped with two four-pole motors of 35 h.p. each, operating on one side of the three-wire system, that is, each motor works under the tension of 600 volts.

The load is usually the same on both motors of one car. In case the load is unequal and the motors take varying current, the track returns the differential current to the return feeder. The rail bonding gives the track a good conductivity, and the independent control of both generating sets at the station allows a difference as high as may be necessary in operation, which would not obtain with coupled generators.

The controllers are placed on the roof of the cars, in a projection near to the resistance boxes. The operation is possible from each platform by means of a handle which the motor-man carries with him from one platform to the other when changing direction. Simple reduction gears are provided to the motors.

When disconnected from the line the motors may be arranged, by a special connection of the controller, to expend their energy by acting as generators and sending current through a rheostat continuously, variable from a maximum value to o.

The trailers are provided with shoes in the form of large magnets suspended from the cars. Electric couplers and jumpers connect them in circuit of the motors acting as generators, these electros having a considerable tractive power and consequently strong braking effect on the wheels. The same shoes can equally be applied mechanically by means of special brake-rigging. The trailers are supplied also with screw-brakes.

The interior and exterior lighting of all the cars is electric, and fed by a circuit derived from one of the sides of the three-wire system. The electric heating of the cars is arranged in the same manner. The heaters are placed under the seats, and their regulation is very easy. The collection of current is made by means of two special trolleys carried on bronze metallic tubes with tips of soft metal. Each tube is pivoted on a separate cast-iron base, supported by porcelain insulators; powerful coiled springs maintain a pressure of 6 kg. on the contacts of the line. The power of the station is such that it can put into circulation simultaneously nine trains of about 30 tons, of which eight are passenger and one a goods train.

The whole electrical installation was carried out by Schneider & Co.

(To be concluded.)

Wire-Bound Ordnance.

By CHARLES BERTHON, Major.
(Late Royal Engineers.)

❀ ❀ ❀

At the commencement it may be stated that the idea of winding wire circumferentially round ordnance for imparting strength is not a new one, there being now in existence, both in England and France, specimens of wired guns hundreds of years old. The wire gun is a piece of ordnance in which circumferential strength is given to a tube or barrel by the process of binding it with steel wire at a tension adapted to resist rupture from internal pressure. It would, however, be more correct to describe what is now in use as "tape" or "riband" rather than "wire." This particular material is employed for the purpose on account of its great strength and the non-existence of flaws. By this method of construction the theoretical conditions of strength are more nearly fulfilled, and the guns are lighter than those made in the ordinary way. The mode of construction in its present form was first patented by Mr. J. Longridge, M.Inst.C.E., though Dr. Woodbridge, an American, claims to have invented the system in the year 1850. Up till the present, however, the U.S. Government have not seen fit to adopt it, in spite of the fact that they have greatly experimented in the direction since that date. In 1871 a Captain Schultz investigated the subject in France, designing quite a number of wire guns, several of which were made for the French Government. The system, however, was not adopted in the gun factories of that or any other foreign Government, the wire guns possessed by many powers being "made in England," either by Armstrong or by Vickers. Between 1875 and 1879 upwards of forty wire guns of different calibres, up to 10 ins., were built at Elswick; but after 1879 the system was abandoned for a time. The ordinary construction seems then to have been considered to afford ample strength, while on the other hand the new system was found to involve the expenditure of too much time, as well as proving itself to be more costly than the ordinary method of manufacture. Of course in the "hoop" construction the wrought-iron hoops could be prepared simultaneously with and independently of the gun tubes, thereby facilitating rapid production of the finished gun.

Two guns in accordance with Mr. Longridge's designs were made—one in 1885, by Easton & Anderson, for the British Government, and the other in 1888, at Aboukoff, for the Russian Government. Both of these guns were of 6-in. calibre, the wire used being in the form of tape one-tenth of an inch thick. Mr. Longridge advocated a thin tube, having a low modulus of elasticity; being of opinion that, if steel wire could be obtained with a modulus of elasticity of 30,000 tons, it would be the best possible material in combination with a tube having a modulus of about 5,500 tons. Ordinary English gun steel has an elastic modulus of about 12,500 tons.

Though experiments in wire binding have been intermittently carried out at Woolwich since 1883, the adoption of the wire method was not seriously contemplated until after 1887, when the startling performances of the 9·2-in.—or so-called "Jubilee"—wire gun attracted so much attention.

The main difficulty in all wire construction is, of course, the provision of longitudinal strength, in order to overcome the tendency to bend, so common in all long guns. The wire itself imparts no longitudinal strength, its sole function being to resist the circumferential, or bursting, strain. All kinds of objections

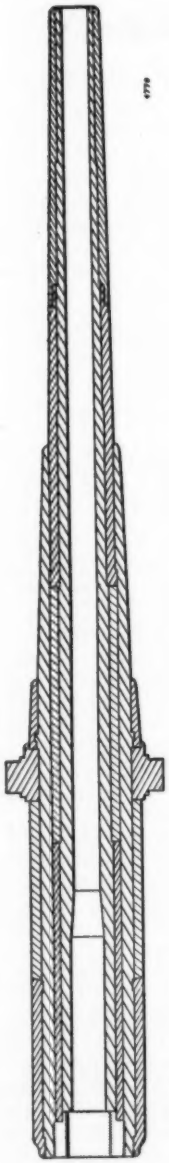


FIG. 1.—SECTION OF AMERICAN 12-INCH GUN OF 40 CALIBRES.

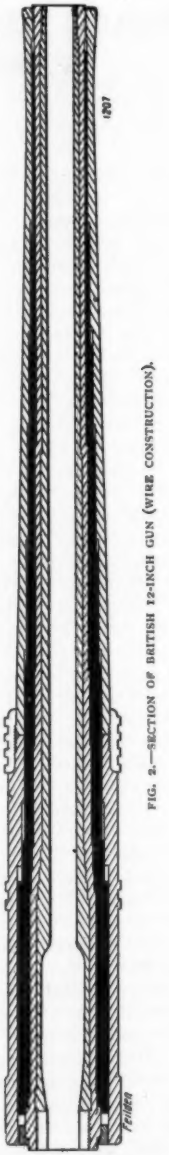


FIG. 2.—SECTION OF BRITISH 12-INCH GUN (WIRE CONSTRUCTION).

FIG. 3.—SECTION OF A 12-POUNDER FIELD GUN (PARTLY WIRE CONSTRUCTION).

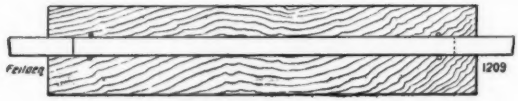


FIG. 4.—HOLDING WIRES IN POSITION FOR SOLDERING JOINT.

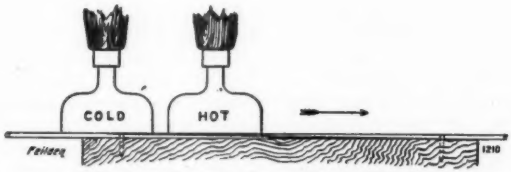


FIG. 5.—SOLDERING JOINT OF WIRES, BEFORE RIVETING.

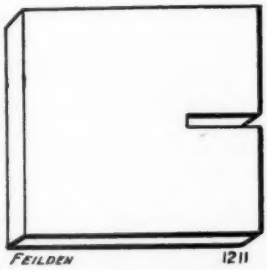


FIG. 6. GAUGE FOR WIRE JOINTS.

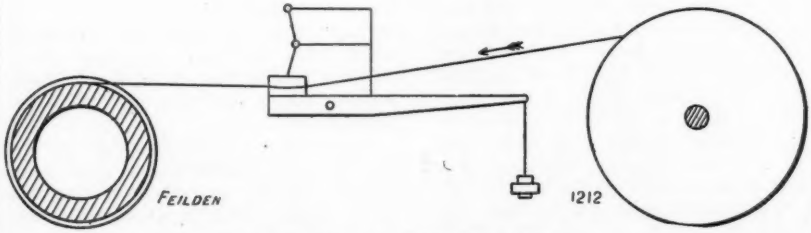


FIG. 7.—DIAGRAM OF WIRE-WINDING MACHINE.

were urged against the adoption of the system. It was said that a glancing shot might cut away the thin covering hoop and "part" several of the wires, while the same kind of shot would merely indent the hoop in a gun of the ordinary construction. As a matter of fact, if the wire does break during winding it unwinds very little, the friction between the parts being so immense. Another of the objections raised was that the heat caused by firing would so alter the dimensions of the gun as to cause variation of the stresses. Further, it was asserted that it would be impossible to bend wire round a cylinder in such a fashion as to ensure uniform tension, and it was not until the early part of 1890 that the Ordnance Committee finally recommended the employment of wire in gun-making. Much has been said of late regarding the superiority of foreign over British guns, but it may very seriously be questioned whether this assertion has any foundation in fact. For, if so, it may very pertinently be asked why it is that so many foreign navies are equipped with British-made guns.

It is true that higher velocities are attained as time goes on, for the simple reason that guns are made heavier and longer in proportion to their calibre. Our 12-inch wire gun (like the American 12-inch piece of hoop construction) is 40 calibres long, the weight of projectile in each case being 850 lbs. At the present time, our tables show the wire gun to have a muzzle velocity of 2,481 feet per second, and the latest American tables give 2,800 feet, the respective energies differing accordingly. This would, at first sight, seem like a triumph for the American gun; but, bearing in mind that no charge has been specified, no genuine comparison can be made. Moreover, the factor of safety is far greater in England than in the United States or any other country. High velocities have been attained in Great Britain with newly-built guns, and the apparent difference mentioned above is fully accounted for by the fact that, the bore having worn out hitherto so quickly, it was considered misleading to give in our Service Tables a velocity *that could only be attained by a new gun.* The new American gun, referred to in the tables, is practically identical with our own, though somewhat heavier; but as our own is of wire construction, it is safe to assume it to be capable of doing all that the American gun can accomplish, given the same powder.

Fig. 1 is a section of the American 12-inch gun in question, Fig. 2 being a section of the British 12-inch B.L. gun mark VIII., Wire Construction. This latter piece consists of a steel *A* tube extending from the seat of the obturator to the muzzle. The main *A* tube is secured longitudinally to the *A* tube proper, by means of corresponding shoulders, and a steel breach is screwed into the *A* tube at the rear end, the breach bush being prepared for the reception of the breech screw. Around the *A* tube are wound successive layers of wire, extending from the rear end of the chamber to within a few inches of the muzzle. A steel ring, forming a stop for the wire, is shrunk on the *A* tube at the breech end. The wire-bound portion of the gun is shown in solid black in the sketch. Over the wire comes the jacket and *B* tube. The *C* hoop, covering the joint between the jacket and the *B* tube, is screwed over the jacket, being prevented from turning, when in position, by means of a steel pin, which is passed through the *C* hoop into the jacket, and secured by a screwed rivet. "Thrust rings" are formed on the exterior of the *C* hoop. The wire commences just above the breech end of the chamber, the first layer extending the whole length, the next layer not extending so far, being "fastened off" to a steel ring shrunk on the layer below, and so on, to make up the remaining thickness, the number of layers being regulated according to the pressure in that part of the gun. There are 12 tons, or 100 miles, of wire on one of these 12-in. guns.

Fig. 3 is a section showing the construction of a 12-pounder field gun, 3-ins. calibre. It will be observed that the breech portion only is bound with wire, as is usual with small guns.

The War Office tests are remarkably severe. The wire which measures 0·25 in.

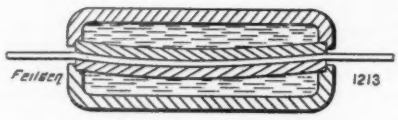


FIG. 8.—SECTION OF WATER-COOLED JAWS OF WINDING MACHINE.

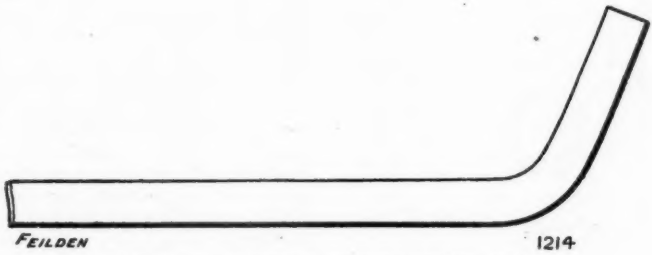


FIG. 9.—WIRE AS BENT FOR FIXING THE END (FULL SIZE).

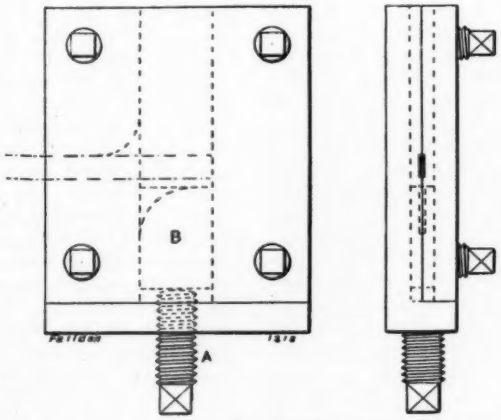


FIG. 10.—WIRE-BENDING TOOL.

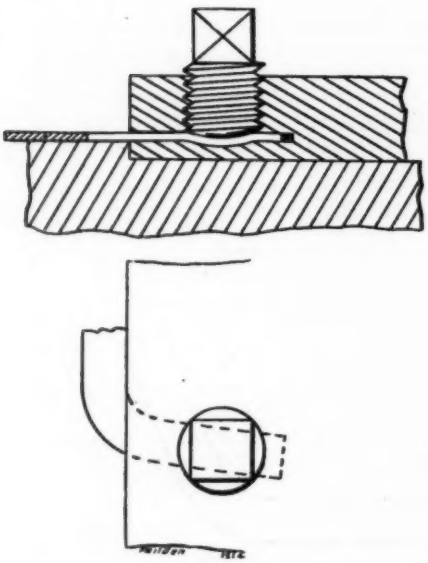


FIG. 11.—PART OF COLLAR SHOWING MODE OF FIXING END OF WIRE.

by 0·06 in., must have a tensile strength of 90 to 120 tons per sq. in. of cross section, the tests being made on a length of 200 ins. Furthermore, a length of 24 ins., hung vertically and supporting a weight of 112 lbs., must be capable of being twisted ten complete turns in one direction, and after being unwound, of being re-twisted in the opposite direction without evincing any sign of fracture. The wire is made from a mild steel, its great strength being obtained from "drawing" in the usual way, whilst its ductility is preserved by annealing, the scale produced by this latter process being removed by pickling. Before the wire leaves the makers' works it is tested in 400-yard lengths, but is not cut off, as an important point is to produce it in the greatest possible lengths.

The process of winding on the wire at the Royal Arsenal, Woolwich, is as follows:—The wire is delivered on drums in lengths of about 800 yds. This naturally necessitates certain joints, but these are avoided as much as possible. A joint is effected by placing the ends of the wire in grooves cut in a steel plate, and then passing them under a revolving cutter. This reduces the ends to a uniform taper, varying from the original thickness down to a knife-edge, and thus forms a bevel 9 ins. in length at the end of each wire. It is obvious that if these two milled surfaces are brought in contact, a uniform thickness of wire will be preserved. The ends of the wire are tinned on the milled side for a length of 3 ins., the surfaces are then brought together as above indicated, and held in position for soldering by nailing them to a flat piece of hard wood, as shown in Fig. 4.

A hot soldering bit, the width of the wire and about 3 ins. long, is next placed on the wire, and moved slowly along over the whole length of the joint, at the same time being pressed down tightly and followed up closely by a cold soldering bit of the same description, as shown in Fig. 5. The hot bit sweats the surfaces together, the cold one absorbing the heat and insuring perfect contact. Thirty-two holes of $\frac{3}{64}$ in. diameter are drilled along the joint and are then slightly countersunk, the whole being riveted up with mild-steel wire. The joint being thus made, it is draw-filed with a dead smooth file, and very carefully gauged. The gauge (shown in Fig. 6) must pass freely along the whole surface, and at the same time fit tightly enough to bear its own weight anywhere on the joint. Joints made in the manner described are practically as strong as the wire itself, but it is necessary to watch them narrowly during a "wind" as they are liable to "start" while being wound upon a tube of small diameter. Two varieties of wire are used in gun-making, one finished bright and

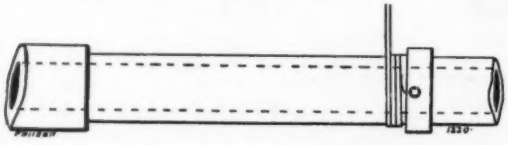


FIG. 12.—PART OF GUN TUBE SHOWING COMMENCEMENT OF WIRE-WINDING.

the other dull. In the former kind the splice is very difficult to see, for which reason the wire is painted red for a length of about a foot on both sides of the joint, to indicate the places where minute inspection is necessary during winding. The tension given to the wire during the operation of winding is from 56 tons per sq. in. at starting to 32 tons per sq. in. at the finish. It must be remembered, however, that varying tensions are never employed in the same "wind." The wire is fastened, as described later, and then wound on the gun tube at a uniform tension, backwards and forwards, forming the required number of layers. It is then finished off, all interstices being filled by loose pieces of wire cut to the exact shape required. The wires of contingent layers cross one another. In order to ascertain that the correct tensions have been given during the binding, the bore of the tube under treatment is frequently gauged. A wire-binding machine consists essentially of a lathe (in which the gun is caused to revolve at a constant rate of rotation) and a mechanism, the function of which is to cause the wire to be wound round the gun tube at a constant, definite tension.

Fig. 7 is a diagram of the machine in question. It will be seen that a lever, of 8 to 1, presses two surfaces together, gripping the wire on its upper and lower sides, and at the same time bending it to the radius of the jaws, thereby setting up the friction necessary to give the desired tension. Tension can be varied by applying more or less weight to the lever. In order to keep the wire cool, the steel friction jaws are set in gunmetal boxes, through which a constant circulation of water flows. The rate at which the wire is wound on is about 70 ft. per minute. Before starting a "wind" the end of the wire is bent to the form shown, its temper having been "drawn," for a few inches, by means of a blow-pipe. The sketch, Fig. 9, is traced from an actual bend, made for fastening the end of the wire before starting to wind, and represents the actual width of the wire. The tool used for making these starting and finishing bends is shown in Fig. 10. The end of the wire is inserted as far as it will go into the slot in the side of the box, the screw *A* is then screwed in, causing the die *B* to bend the end of the wire to the required curve. During this operation the wire cannot buckle or twist sideways, being kept perfectly flat by means of a slot in the die. In winding, the wire is always started from a collar, which is either shrunk on, or integral with the tube, and each length of wire is "fastened off" to a collar, these collars being provided with numbers of set screws with square heads. A slot is cut in the collar leading to the bottom of each set screw, into which the bent end of the wire is put. The set screw is then screwed home as tightly as it will bear. The set screw, being rounded off at the end, slightly "dishes" the wire; and further, as the pull during winding comes at right angles to the hole in the collar, it will be seen that the end of the wire is very securely fastened.

Fig. 11 shows a set screw gripping the end of the wire, and Fig. 12 represents part of a tube, upon which the winding has been commenced. On completion of the wind the wire is fastened in a similar manner; but, as it is necessary to keep all the tension, a bridle or clamp is bolted tightly round the bounden wire before allowing the tension of the winding machine to be taken off. This device effectually prevents any "slacking off." The wire is next cut off to the desired length, the temper of the end being "drawn" and bent, as before described. The bent end is then inserted under a set screw, and fastened. After the winding is completed the screws are cut off flush with the collar. The accuracy with which binding is done may be imagined from the fact that after twenty, or even thirty, layers of wire have been wound on the outside layer may be "skimmed" in a lathe, without reducing the diameter by more than $\frac{1}{100}$ of an inch.

On completion of the wire binding the outside hoops are shrunk on—an extremely delicate process, and one calling for the greatest skill and judgment. Forgings for the tubes and hoops are made from steel ingots of peculiar shape, which is that of an octagonal truncated cone, super-

posed on a short abruptly-tapered circular base. The narrower part of the ingot is on the top, and as in consequence it contains impurities, a great part of it (about one-third of the whole) is cut away. The circular base is also removed. The defective material having thus been taken away, a test of the steel, for the maker's satisfaction, is taken, and upon this proving satisfactory, the ingot is trepanned. This is done with a hollow boring-bar, so that a circular core is cut out in the form of a solid bar, which is available for other uses. When, however, the ingot is short and the forging to be made from it is long, the whole substance is generally required, for which reason a hole is pierced only large enough for the insertion of a mandril. Very little forging is done now-a-days under the hammer, this being superseded by the hydraulic press, which is found to be far superior. These presses act at from 2,000 to 5,000 tons.

Hydraulic forging presses are always vertical; the head being rectangular and flat-faced, the anvil for circular work having a large triangular notch. This not only keeps the work truly in place as it is tuned round and round, but also distributes the pressure equally.

The forgings for the barrel of the 12-in. wire gun are about 43 ft. long, with an internal hole between 9 ins. and 10 ins. diameter. This is a great length for a hollow forging having so small a hole, but failures are very rare. After forging the hoop or barrel is annealed—that is, raised to a high temperature, and then allowed to cool very gradually. This removes internal stresses set up by the process of forging, and after being annealed the forging generally requires straightening, which is done in a hydraulic press. It is then rough turned and bored, and test pieces are cut off. Upon the next two operations the working strength of the steel depends. The forging is first heated to a temperature between 1,450 degs. and 1,600 degs. Fahr., and is then lowered direct from the furnace into a well of rape oil, where it remains to cool. The effect of heating steel and of cooling it rapidly

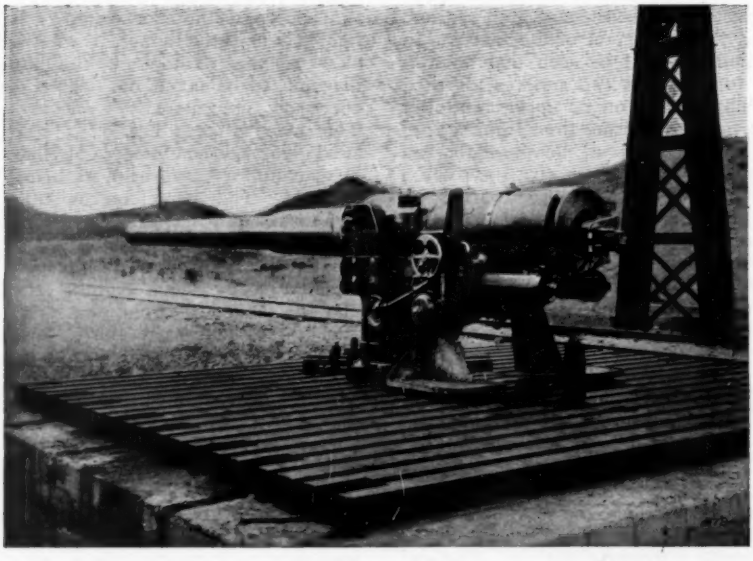


FIG. 13.—6-INCH GUN ON PEDESTAL MOUNTING BY MESSRS. VICKERS, SON AND MAXIM.

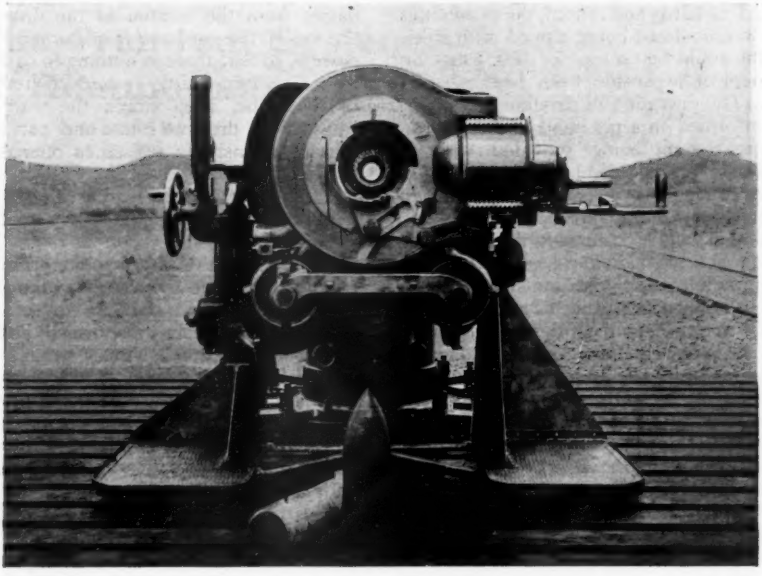


FIG. 14.—BREECH MECHANISM FOR VICKERS 6-INCH GUN.

is of course to increase its strength considerably; but it also decreases its ductility, and at the same time internal stresses are set up. With a view to keeping these as low as possible, rape oil is employed instead of water, as its heat conductivity is lower, and consequently the effect on the steel is less sudden. Nevertheless the steel is not in a fit state to use. The forgings are again heated to about 1,000 degs. Fahr., and allowed to cool slowly, after which operation further test pieces are cut off. Tests are made upon these, and according to the results obtained, the forgings are passed or rejected. When passed, they are again turned and bored to within one-tenth of an inch of the finished sizes.

Boring is done with a fixed boring-bar, the work revolving, the finishing cut being made by pulling, *not* pushing, the boring-bar through. In shrinking a hoop upon a small gun, it is generally sufficient to be sure that it is hot enough, hence gauging it inside is not requisite. The hoop is simply raised over the up-ended gun, and lowered gently until it is within, say, a foot of its destined position, when it is let go, and drops by its own weight, the shoulder on the hoop and that on the gun coming into complete contact. Water is then sprayed all round the shoulder end (bottom) of the hoop, while the upper portion is kept hot by means of rings of gas flames produced by ordinary illuminating gas, and intensified by the air blast. The shoulder end is thus locked by contraction into the joint, and its further motion in either direction is arrested. As the hoop continues to contract, not only in length, but also in diameter, the shoulders within move slightly in a breechward direction, and press harder and harder against the corresponding shoulders on the hoop or barrel beneath. This enables the gun better to withstand longitudinal strain, and also to resist natural bending stresses.

The shrinking on of a big hoop is a precisely similar operation, the only difference being that inside gauging whilst hot is indispensable. For this purpose a

long T of hardwood is used, the extremities of the cross-head being tipped with steel. Metal would be useless for this gauge on account of expansion from heat when in use. The operation of shrinking on hoops is performed in a pit lined with cast-iron plates, the pit being provided with an overhead crane, capable of picking up a piece of a gun anywhere in the pit, and of depositing it in any other part.

The details of construction at Elswick are practically identical with those at Woolwich, except in a few minor details, which will be apparent. Among a large number of wire guns of different calibres, for British and foreign governments, a great many 12-in. guns, similar to that illustrated in Fig. 2, have been constructed at Elswick. Those for the Japanese Navy vary in several important particulars from the British gun of 12-in. calibre, made collaterally with them at Elswick. The Japanese gun is only strengthened with wire at the rear half, about five tons of wire being used, as against twelve tons in our own pattern, and the arrangement of chase hoops differs accordingly. Very long hoops cannot in consequence be employed, and two shorter hoops with a step-down are therefore substituted, a double barrel being dispensed with.

The Elswick winding machine is placed on a long lathe bed, parallel with the rotating lathe, and of about the same length. It consists of a drum, supported on a stout steel spindle, the wire being wound upon the former. The rotation of the drum is controlled by a brake wheel supported on brackets and surrounded by a woodblock brake. One end of the brake band is attached to a Salter's spring-balance hung from a bracket, and the other end carries a suspended plate, upon which the requisite weights are placed, while a continuous and copious supply of lubricant pours over the brake. The wire passes from the bottom of the drum to the top of the gun, *and is untouched in its passage*, so that there is nothing to damage it. The gun being caused to revolve in the lathe, itself draws the wire on, causing the drum to rotate and part with its wire against the resistance offered by the brake.

This resistance is readily altered by manipulating the weights, the actual resistance being shown on a dial. The remoteness of the wire machine from the gun leaves ample room for a workman to stand close behind the gun to see that the wiring is properly performed, and he makes sure that the wire is wound well up into place by tapping it with a copper drift. The fact of the wire being practically untouched in its passage from drum to gun renders it possible to wind at a speed about double that which is possible with the Arsenal machine.

Messrs. Vickers, Son & Maxim are manufacturing a large number of wire guns for the British as well as for foreign governments, but as their method of construction is practically identical with the Arsenal practice already described, a few remarks on details only will be made. As usually made, the screw to the breech block is so interrupted that threaded and plain surfaces alternate for equal parts of the circumference, the result being that only one-half of the circumference is available for resisting the pressure of the explosion. Vickers' breech block, as illustrated in Fig. 14, is divided circumferentially into segmental portions in regular steps, but of varying radii. The block for the 6-in. gun has eight segments, six of them being threaded, hence three-fourths, instead of one-half, of the circumference is available. This enables the breech block to be materially shortened. Fig. 13 is from a photograph of the 6-in. quick-firing wire gun made by Vickers, Son & Maxim, with centre pivot mounting.

The Premium System of Remunerating Labour.*

By Mr. JOHN ASHFORD, M.I.Mech.E.

THE successful working of a manufactory depends largely upon the system of remunerating workmen for their labour. Especially is this the case where such workmen have to attend the working of costly machinery, the output from which depends to a considerable extent upon the workman's ability and his attention to his work. This may be said to be essentially the conditions in an engineering workshop where a large portion of the work is done upon machine tools.

We may take it that one of the first commercial principles of manufacturing is, that, with a given selling price for the article produced, a certain output must be reached and exceeded, before expenses are covered in the particular manufactory and the making of profit begins; and, that having passed that point in output, the proportion of profit increases rapidly as the output is enlarged.

The scheme of remuneration will undoubtedly militate towards increasing or retarding the production and, therefore, will have a very considerable effect upon the business.

The chief systems that have obtained up to within recent years, have been either day work with payment by the hour, or piecework. If payment is by the hour, the workman has little inducement to press his machine to produce the maximum output, and the extent of his efforts is generally limited to the amount he considers will satisfy his employer, and a satisfactory output is usually only obtained by "horsing" on the part of the staff.

There are but two ways of getting an individual to exert his maximum effort; firstly, by driving, and, secondly, by offering inducement. While many are tempted to adopt the driving principle it cannot be considered satisfactory to anyone concerned, certainly not to the person driven. It is possible only to drive down stipulated roads, and the driven are not likely to use their brains in seeking for short cuts. On the contrary, create a sufficient inducement, and the individual will use his wits in devising means to reach the objective by easier ways and in shorter time.

In the case of remuneration by the hour, there is but little in the nature of inducement beyond the retention of the situation. The only real inducement is the somewhat uncertain one of a possible increase in the rate of remuneration, and this, normally, is very remote when a man is already receiving what is known as *full rate.*

In the case of piece work, an inducement is created of a somewhat doubtful character, for the man is aware that if he exerts himself to the extent of obtaining more than the limited increase upon his normal wage, the piecework price will be reduced. The real tendency of piecework, unless administered by a very competent staff, is, then, rather the reverse of what was intended, for the worker will be careful that he does not earn more than, say, time-and-a-quarter. Thus it is possible that instead of being a reasonable inducement to the worker, it may in effect have a decidedly retarding influence. It might be argued in favour of piecework that if prices are correctly set, such retardation is impossible. Such an argument is obviously based upon the assumption that finality has been reached in the matter of speed of production, or an acceptance of the unsatisfactory principle of piece-cutting. Another serious aspect of piecework is

* This interesting paper, which was recently read before the Manchester Association of Engineers, has, on account of its importance and by reason of the fact that the proceedings of this society are not accessible to the majority of the readers of FEILDEN'S MAGAZINE, been reprinted here.

that it is based upon a system of bargaining, for it presupposes that a price per piece is agreed upon between the worker and the employer, by which the former agrees to do the work at a certain price. Such a species of bargaining places the employer and the worker at two opposite extremes, and this naturally leads to a species of antagonism that engenders the reverse of friendly feeling. The effort of the employer to get his work done cheaply, and so to place himself in a better commercial position, is thus likely to cause estrangement between his workers and himself. It is a matter of history that many strikes have resulted from the estrangement originating in differences as to the fixing of piecework prices. The chief failing point in piecework may be said to rest in the fact that an alteration in the price in favour of either of the contracting parties is bound to be to the detriment of the other, which means a clashing of the interests of the employer and workers.

It will no doubt be accepted without controversy that providing a system of remuneration is found that establishes a community of interests between the employer and his workers, whereby it is to the interests of both to increase the output of the establishment, there will be harmony of feeling and a much greater probability of attaining the desired results.

Provided that the worker finds it is to his personal interest to get the maximum amount of work from his machine, no doubt he will take steps to get it; and if he finds another able to obtain better results than he in a different way, he may be trusted to adopt the other's methods. If he finds that by thought and scheming on his own part, he can do better for himself, he again may be trusted to look after the matter.

Various methods have been tried for giving the worker this personal interest, such as profit sharing, preferential piecework, and more recently the premium system of remuneration.

As to profit sharing, when applied to the ordinary worker, it may be said to have generally failed; for the advantage to be gained seems to him somewhat problematical and remote, as his best efforts may be nullified by the fault or mismanagement of others.

Differential piecework is a partial solution of the problem, of which the possibilities are, in the author's opinion, too narrow, and, while an improvement upon piecework, it suffers from some of its faults.

The premium system is of more recent development; and, when worked in a proper manner, undoubtedly creates that inducement to call forth the best efforts of the worker. This system may be said to be a method of remuneration which places a premium upon effort and intelligence: the greater the effort and the higher the intelligence displayed by the worker, the more becomes his personal return. It may further be said to be a method of remuneration which ensures to the employer a reduction in prime cost, of increasing magnitude as the worker's return becomes greater; thus unity of interest is created.

The premium system, as it is now understood, was introduced by Mr. F. A. Halsey, at the works of the Canadian Rand Drill Company of Sherbrooke, in 1890. His scheme was to take the time that a job had previously taken by daywork, and offer a premium at the rate of one-third a man's wage per hour for each and every hour that he saved. Thus the man was paid for his time at time rate, and was given, as an inducement to shorten the time of doing the work, a premium equal to one-third of the time saved at his own rate. In establishments where work is continually repeating, and where cost keeping has been sufficiently detailed to form exact records of times spent by daywork upon the various jobs, this general scheme upon a daywork base may be employed, providing that the hourly bonus is not too high. It has been found by experience that the time taken to do certain work by the hour may be reduced to an unexpected extent when an inducement is given the worker; consequently, if the hourly bonus is too liberal, the employer, when he finds how little time is really necessary to do the job, will be strongly tempted to reduce the allowed

time. This temptation, however, must be resisted, as the fact of cutting would destroy the harmony existing between himself and his workers, and thereafter he would fail to get their best efforts from them.

The more usual plan followed is for the worker to be paid his hourly wage, and to work against a time set by the management, called a standard time. If the worker completes the work within the standard time, he is paid a premium equal to some proportion of the difference between the time taken and the standard time. There is no recognised proportion that constitutes the premium, any more than there is any recognised standard time, apart from that in each individual establishment.

The original idea of premium working may now be found in several different forms, although the underlying principle is the same. Probably the most important diversion from the original Halsey scheme, is that introduced by Mr. James Rowan, of Glasgow, the chief point of variation lying in the method of dividing the difference between the standard and the actual time. Whereas in the original Halsey scheme the difference was divided in a pre-arranged proportion, in the Rowan application the premium consists of a percentage calculated upon the actual time, in the proportion that the saved time is a percentage of the standard or allowed time.

Thus if the worker completes his job in 20 per cent. less than the standard time, he is paid his hourly wage for the actual period, plus a premium of 20 per cent. of the same. The practical difference between the two methods is, that the premium reward to the worker upon the Rowan system is greater in proportion to his effort for the lower savings that are effected, and less in proportion as the saving becomes greater.

By the Rowan method the worker receives the greater proportional reward when the time is reduced to 75 per cent. of the standard.

In the Halsey method the return of the worker is somewhat less for the lower proportion of saved time and greater for the higher proportion. The comparison of the two methods is more clearly shown by the aid of a diagram. See Diagram I.

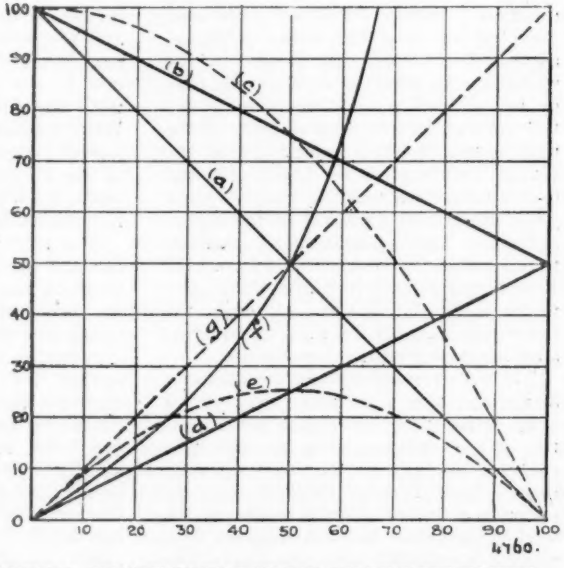


DIAGRAM I.—COMPARING HALSEY 50 PER CENT. AND ROWAN PREMIUM SYSTEM.

Scale of reduction in time: Curve (*a*) Time per piece; Curve (*b*) Cost per piece (Halsey) 50%; Curve (*c*) Cost per piece (Rowan); Curve (*d*) Premium per piece (Halsey) 50%; Curve (*e*) Premium per piece (Rowan): Curve (*f*) Premium per cent. (Halsey) 50%; Curve (*g*) Premium per cent. (Rowan).

In this diagram several curves are plotted that bring into comparison the Halsey 50 per cent. premium system and the Rowan system. For convenience of comparison it is assumed that the daywork or standard time is 100 hours, and the curves are plotted on the assumption that there is a steady reduction by the worker of the actual time taken to do the job from

100 hours to nothing, in order to make the diagram complete. The upper pair of curves starting from 100 indicate the actual cost of the article as the time is reduced. Both methods show a steady reduction of cost, and it will be observed that the Halsey system gives the lower cost until such time as the worker has reduced the actual time to one-half. For time savings in excess of 50 per cent. the Rowan system shows a lower wages cost.

Turning now to the worker's side of the question. Starting from zero, the two lower curves show the actual premium, expressed in hours, that is paid to the worker for his efforts in reducing the time on the job. The lines representing the two systems will be seen to cross at the middle, the first half indicating that the Rowan system gives the larger premium to the worker, whereas the Halsey system gives the greater premium in the higher savings of time. The author is inclined to think that the worker would favour the Rowan system as giving him the greater return for the least effort, although the inducement cannot be said to be great after the 50 per cent. is reached.

The worker would probably look askance at the fact that if he saved over 50 per cent. of the time, his actual balance on the job decreases, although the percentage to his working time steadily rises. The Halsey method, on the contrary, offers great inducement to the worker to aim for the higher time savings, as offering him return commensurate with the higher tension of his effort. The two curves springing from zero and mounting to the higher parts of the diagram, represent the percentage of the premium to the actual time. The rapid rise of the Halsey percentage over the 50 per cent. point is a matter for observation, and in the opinion of some, this constitutes a danger to the success of the system.

Considering the points in common between the two systems, perhaps the most important, and one upon which full stress should be placed, is the idea of taking a standard time for a given job, that shall be unalterable so long as the same method of machining and quality of machine tool are used. The success of the whole system depends upon the continued adherence of the parties concerned to this principle, as forming the basis of mutual confidence. There is no necessity, neither inducement, to a reasonable employer to desire or to try to cut down the standard time when once it is fixed, even though the worker should obtain premium running into high percentage, when in spite of that fact the prime cost of his article is less. This is one of the important differences between premium and piecework, for with the latter, whatever balance the worker makes, the wage cost to the employer remains the same until such time as he cuts the price. What matters it if, under premium, the worker makes high wages? The concern of the employer or manager is to make profit, not what it is necessary to pay away in order to make that profit.

The next point is, that in spite of the fact that the system may be based upon a standard rate of wage, it opens the door for individual merit in the worker to find recognition and reward.

A further feature which has grown up around the premium system, is the principle that the worker is guaranteed his hourly wage without reduction, whatever the time in which the job is completed, and that there is no debt. It is a common experience in piecework that, when a worker from any cause, gets into debt and sees no prospect of obtaining extra remuneration on other usually paying jobs, he loses heart and allows other work to slip into debt likewise, until there is no chance of clearing himself by other balances. He then either leaves his situation to start free of encumbrance elsewhere, or the debt has to be forgiven. With premium there is no debt, each job, which may consist of one or more articles, stands alone in its reckoning; and, although in a previous job he may have been unfortunate and have run behind, he starts clear with renewed opportunities and fresh inducements to put forth his efforts.

In the case of piecework, it may be necessary to give various prices for the same job to differently rated men: not so,

however, with premium, as time counts the same whatever the rate, with special exceptions.

In establishments where overtime or night shift may be worked, piecework contracts occasion much discontent; for the price is usually kept the same although the rate of pay becomes time-and-a-quarter or time-and-a-half. In the case of premium one hour counts one hour, whether by day or by night. The reasoning associated with this principle is, that the overtime is worked by the employer's desire and especially for his benefit, and that, therefore, such extra cost as it entails should be met by him.

Queries may be advanced as to how the premium system may be successfully worked in such comparative instances as where:—

A. One man works one machine.
B. One man works two machines.
C. One man works three machines.
D. An apprentice boy works one machine.
E. An improver works one machine.
F. One man and one boy work two machines.

The author has met these several cases in what proves to be a satisfactory way, basing his reasoning upon the ideas that it is desirable—firstly, that from the employer's point of view one man should work several machines; secondly, that from the worker's point of view, if he operates several machines, he shall have a sufficiently increased return as an inducement; and thirdly, that a boy, inexperienced in the use of a machine, requires more time to get through a given piece of work. Considering—

A. That one man working one machine is allowed an amount of time equal to unity 1
B. The time allowed for work on each of two machines shall be two-thirds that allowed in case A, giving a total for the two machines of ... ... $1\frac{1}{3}$

NOTE.—Where an operator works several machines his time is evenly divided when booking to the work on each machine. The extra one-third time allows a margin for the slight loss of time on each machine by divided attention, and leaves a margin for extra premium.

C. The time allowance for each machine is, in this case, one-half that of case A, giving a total for the three machines of $1\frac{1}{2}$
D. Instead of changing the time allowance for an apprentice the case is met by charging to the job one-half of the time taken (half-time charged) ... 1
E. For an improver who is earning less than a sovereign a week the time allowance remains constant, but the time taken is charged as three-fourths (three-quarter time charged) .. 1
F. To meet this case the time is initially taken for each machine, as in case A, and three-fourths of that is allowed, making a total for the two machines of. $1\frac{1}{2}$

NOTE.—As an inducement to a man to partner with a boy in this manner, the boy charges his time at one-half, the same as an apprentice working one machine; and to obtain a suitable division of time, both the man and the boy book a half of their chargeable times to each machine.

In the average establishment certain degrees of accuracy must be obtained for the work to be satisfactory, and it is necessary to have some form of inspection to decide when a sufficiently high standard has been reached. The standard required should be made as clear and distinct as possible, and there should be but little opportunity for the exercise of personal opinion as to whether the work is or is not passable. To establish a deciding line it is generally advisable to have some form of limit-gauge system of measurement, with the clear understanding that if the job fails to come within the limitations it may be scrapped, and upon scrap no premium is paid. This understanding may be supplemented by an arrangement to the effect, that, although a job is outside the allowed limitations, it may, by the expenditure of further time and money in other processes by way of correction, be made good enough; one-half premium only will be paid, the remaining half going towards the cost of making the job usable.

In the event of material proving faulty to the extent of making the job of no value for its object, it constitutes a loss to the employer to the extent of the hours spent upon it, and the worker receives no premium. This remark does not apply to any completed machining operations prior to the one during which the fault declared itself. This is a perfectly fair arrangement, for the operation would cease at the discovery of the fault, so would never be completed.

When an employer is considering the advisability of introducing the premium system into his establishment, he would naturally formulate queries as to what it entailed in the way of administration, and what might be the best methods of procedure. The author would here venture a word of warning. Do not touch the premium system unless fully convinced as to its advisability and adaptability to the case, and then only with a firm determination to carry it right through.

The initial work is both arduous and costly as compared with some other systems. It also takes time to get into working condition, and the work of organisation must be thoroughly tackled. The whole work should be under the direction of a competent man, and there should be no attempt to half do it. To put the work of time-setting upon the frequently over-burdened shoulders of foremen would be fatal to its success, as any hurried estimating of times is certain to cause dissatisfaction to either the worker or the employer. The fact that the times when set are to be standard, means that the machining operations must be carefully considered, and times assessed for every operation that constitutes the whole work upon the job.

Full records of the detailed time-setting should be preserved for reference, as should also the times required to do the work, as this becomes valuable information for future guidance. This, in an establishment of moderate dimensions, means an amount of work which will call for a staff of trained men constituting a time-setting and recording department.

The time-setting sheet used by the firm with which the author is connected, is shown in Appendix A., with illustrations

Appendix A.

SPECIMEN TIME SETTING SHEET.

Machine No. 1. *Sheet, No. 859.*
Job—Distance, Piece.
Catalogue No. 250. Drawing No. 4,154. Date 19/11/02.
Boring.

Process.	Tool.	Feed.	Speed.	Cut.	Finish.	Time.	Remarks.
1 Roughing 2 cuts		16	B 2		No. 6	156	
2 Finishing 1 cut		12	B 2		No. 1	52	
3 Face-up		Hand	...		...	15	
4 Chamfer 2 places		...	...		...	30	
5 Bore for plate, 2 cuts ...		..	...		...	20	
6 do. finish ...		...	...		No. 3	10	
7 Recess for plate		...	...		...	40	
8 Handling		...	...		...	150	
						473 min. net = 8hrs say	

Add allowance for balance ....

Finishes.

No. 1. Best, accurate to ·001 in.....Time Fixer.....
No. 2. Good, accurate to ·002 in.
No. 3. Medium, accurate to ·005 in.
No. 4. High Polish.
No 5. Left board cut or water.
No. 6. Rough Machine.
No. 7. Left ·010 in. full for grinding.
No. 8. Left for forcing fit.

of its use on two typical jobs. Examination of these will show that the work of time-setting is done in a methodical way, with due consideration of the feeds and speeds of the machine that are possible as applied to the particular job.

It is found by experience that by observing the time spent in various ways upon particular pieces of work, that of the total time required to do the work, a certain proportion is, of necessity, spent upon the work that may be broadly classed as handling, and that the remainder of the time is spent in actual cutting operations. The handling time would consist of preparing the machine, lifting in the work, setting tools and grinding same, gauging, etc., and that with different kinds of jobs, this handling time may be of differing percentages of the total cutting times, varying between wide limits.

When such observations are made and recorded it very much simplifies the work of time-setting, for it then becomes merely necessary to work out the surfaces to be tooled, and the time required to machine them with given cuts, feeds, and speeds. Of the net tooling time so obtained, the handling percentage is taken and added thereto, producing a total which indicates the net time in which the job can be done. Upon this time, a further addition should be made in order to give the worker an opportunity of making a suitable premium. When considering this added time, in general, it is not advisable to cut things too fine. It rather pays to err on the side of generosity than to be niggardly in this matter, as it is generally found that with finely cut time, the actual time spent upon the job by the worker is greater than if more liberal time is set. This no doubt is due to the moral effect produced. Thus the author would repeat, that considering all things, it pays to be somewhat liberal in time-setting rather than the reverse.

As an aid to time-setting, the author would indicate a few ways of easing labour. As frequent reference has to be made to the feeds and speeds of machines, a carefully compiled series of tables should be prepared of every machine tool, with its capacity, feeds and speeds, together with any remarks as to its tool equipment, faults, etc. (See Appendix B.)

When a series of similar jobs of varying sizes have to be machined, it is convenient to take some proportionate dimension, and plot along the abscissæ of a diagram and the allowed times as ordinates, producing a curve of times for a given machine, taking the extreme and several intermediate sizes. From such a diagram other times may be read as required.

For instance, for plain turned jobs of varying lengths and diameters, a multiple of the diameters into lengths may be set off along the horizontal of a diagram, with allowed times as ordinates, as in Diagram 4. Such diagrams may be extended very considerably, as in Diagrams 2 and 3, which the author has prepared for time-setting on turret lathes dealing with bar work, and in Diagram 5. It is possible with such diagrams to allow for the various failings or facilities for production of the different machine tools available for the class of work by adding other lines of proportionate values. This is clearly illustrated in Diagram 4 and Diagram 5.

Another little convenience is Barth's time-setting card. If this is modified to suit individual machines by adding an extra circle and pointer with lines indicating cone steps, it is possible to drop immediately upon the cone steps required to give the nearest cutting speed to that best suiting the job, together with the time required for machining.

No doubt readers will readily think of other labour-saving methods of simplifying the work of time setting.

For filing the standard times and records, probably a suitable card system has advantages over books. Both the front and reverse of a card, arranged by the author for this purpose, are illustrated in Appendix C. This card, together with the others illustrated, is used in the establishment where the author has introduced the premium system.

As the whole matter is based upon time, some suitable means of checking the starting and finishing times must be employed to ensure correct bookings. This may be done upon a job card or progress ticket, such as is illustrated in

Appendix A.

SPECIMEN TIME-SETTING SHEET.

Machine No. 104. *Sheet No. 1,134.*
Job No. 12.—Crankshaft.
Catalogue No. 041. Drawing No. 5,560. Date 23/12/02.
Turning (previously roughed on body).

Process.	Tool.	Feed.	Speed.	Cut.	Finish.	Time.	Remarks.
1 Centring and setting-up ...		...	...	..	...	4·0	
2 Turning ends for throws ...		8	A 2	...	...	2·0	
3 Lifting out & setting-up throws		...	...	...	...	2·45	
4 Balancing, etc.		...	...	...	...	3·15	
5 Roughing h.p. pins and webs		8 & 16	B & A 2	$\frac{B}{16}$	...	5·30	
6 Finishing do. ...		8 & 16	D 2	...	No. 1	3·0	
7 Radiusing do. ...		Hand	B 2	...	...	1·15	
8 Filing out oval and lapping ...		...	...	...	No. 1	5·0	
9 Change centres to l.p. pin ...		...	...	...	...	2·0	
10 Roughing l.p. pins and webs...		8 & 16	B & A 2	...	...	5·30	
11 Finishing do. ...		8 & 16	D 2	...	..	3·0	
12 Radiusing		Hand	B 2	...	...	1·15	
13 Filing out oval and lapping ...		...	...	...	No. 1	5·0	
14 Changing centres to l.p 2 ...		...	...	...	...	2·0	
15 Roughing l.t. pins and webs...		8 & 16	B & A 2	...	...	5·30	
16 Finishing do. ...		8 & 16	D 2	...	...	3·0	
17 Radiusing do. ...		Hand	B 2	...	...	1·15	
18 Filing out oval and lapping ...		...	...	...	No. 1	5·0	
19 Changing centres to webs h.p.		...	...	...	...	2·0	
20 Roughing h.p. webs		8	A 2	...	...	1·0	
21 Finishing		8	D 2	...	No. 5	1·0	
22 Repeat 19, 20, 21, twice ...		...	...	..	...	8·0	
23 Change centres to body ...		...	...	...	...	5·0	
24 Turning body rough		8	A 2	...	...	5·30	
25 Rough webs outside		16	A 2	...	...	4·0	
26 Reducing radii		Hand	A 2	...	...	2·0	
27 Finish body		8	C 2	...	No. 1	9·0	
28 do. webs outside		16	D 2	...	No. 5	6·0	
29 do. 8 radii		Hand	C 2	...	...	2·40	
30 File and lap body		...	...	...	No. 1	9·30	
31 Change for end		...	...	...	...	·45	
32 Rough do.		...	A 2	...	...	2·0	
33 Finish do.		...	A 2	...	...	1·0	
34 Lap do.		...	...	...	No. 1	1·30	
35 Add for grinding, gauging, craning, etc.		...	..	...	...	13·30	
						145·40 Net time.	

Add allowance.....

If loose steel centres required, add for boring-up, etc., 11·0.

Finishes.

No. 1. Best, accurate to ·001 in.....Time Fixer.....
No. 2. Good, accurate to ·002 in.
No. 3. Medium, accurate to ·005 in.
No. 4. High Polish.
No. 5. Left broad cut or water.
No. 6. Rough Machine.
No. 7. Left ·010 in. full for grinding.
No. 8. Left for forcing fit.

Appendix D. This ticket is issued to the workers by a ticket clerk who fills in the necessary information respecting the job, together with the man's name, number, and the machine number, and he also punches the ticket in the square corresponding to the starting time, differently shaped punches indicating a m. or p.m. At the completion of the job the ticket is again punched in the portion of the ticket on the reverse marked finishing time. This enables the time spent on the job to be calculated. In the event of a job being suspended from any cause, a note to that effect is made upon the ticket, and the time of resumption is also stated.

The advantages of the premium system of remuneration have only been partially stated when the bald system has been explained, for its effect in various other directions is decidedly pronounced. From a managing point of view, it is of great assistance in watching expenditure, and also in observing the capabilities and smartness of the workers, for, by the tabulation of results, attention is spontaneously called to those jobs that have taken excessive time.

A full use of the time-setting department is also of advantage in estimating the expenditure that is likely to be incurred on a given machine, and if the whole work of time setting is done from drawings in advance, it would give an opportunity to alter designs to cheapen cost, if necessary.

Appendix B.

SPECIMEN SCHEDULE OF MACHINE TOOL DATA.

VERTICAL BORING MILLS. *Sheet No. 7a.*

Machine No.	Description.	Capacity. Dia.	Capacity. Depth.	No. of Speeds on C. S.	Speeds (revs. per min.). Double Gear.				Speeds (revs. per min.). Single Gear.				Feeds (per inch).				Remarks.
		Ft. In.	Ft. In.														
155	Vertical Boring Mill double gear 4½ to 1	5 0	3 6	1	1½	2½ 5½	3	4	7	10 24	13½	18	2¾ 12	4 16	8 32		Gear feed.
	Vertical Boring Mill double gear 6 to 1	3 3	2 6	1	1½	2½ 7½	3½	5	11	15½ 44	22	31	2 10	2½ 12	3 16	4 32	8	Gear feed.
122	Vertical Boring Mill double gear 16 to 1 and 4 to 1	4 0	1 10	2	1½ 1¾ 6 7	2 2½ 8½ 10	3 3½ 12 14	4 5 16 20	24 28	34 40	48 64	64 80	2¾ 12	4 14	5 16	8 32	10	Friction feed.
135	Vertical Boring Mill with turret, double gear 6 to 1	2 8	0 11	2	2¾ 3½	4½ 6	7 9½	11 15	16 22	27 36	42 56	66 90	4 10 32	4½ 12 48	5 16 20	6 20	8 24	Friction feed.

The full commercial advantage to be reaped by the aid of the premium system can only be realised by glancing at other results. Take, for instance, the prime cost of a given article. This does not merely include the workers' wage, but other items which may possibly represent much more to the firm, for instance, the actual hourly cost of a machine. The very fact of having a machine within a

Appendix B.

SPECIMEN SCHEDULE OF MACHINE TOOL DATA. *Sheet No. 13.*

MILLING MACHINES.

Machine No.	Description.	Spindle.		Will admit in.		Traverse of Table.		Speeds (revs. per min.).										Feeds (per inch).			Remarks.
								Double Gear.						Single Gear.							
		Dia.	Trav.	Dia.	Depth.	Longitudinal.	Transverse.														
		In.	In.	Ft. In.	In.	Ft. In.	Ft. In.														
69	Vert. Milling Machine double gear to spindle 4 to 1	3	7	3 0	12	2 0	1 6	21	34	54		84	136	216				96	128	172	With Circular Table.
	Vert. Milling Machine double gear 6 to 1	3¼	12	2 9	16	4 4	1 3	10	13	18		60	80	109				0·44	0·68	0·9	Feeds driven from countershaft with circular Table, etc. (Two of these Machines.)
								With slow C.S. speed.				Slow C.S. speed.						1·0	1·8	1·8	
								24	32	44		146	200	272				1·48	1·7	2·0	
								Fast C.S. speed.				Fast C.S. speed.						2·25	2·5	3·0	
																		3·43	3·7	5·12	
																		7·5			
	Hor. Milling Machine double gear 6 to 1	3¼				3 6	0 8	16	21	24	32	96	126	144	192			5	9	10	Feeds from spindle given. Feeds from C.S. not belted. (Two of these Machines.)
									36	48			216	288				15	18	24	
																		27	30	34	
																		38	48	50	
																		54	68	76	
																		100			

workshop means expense, and each hour a job is upon a machine, costs an amount equal to the workers' wage, plus what may be called the machine cost. This machine cost would comprise the interest on capital it represents, its depreciation, the power to drive it, its share of the interest on building proportionate to floor space, building depreciation shop lighting and cleaning, and, say, works' management, these items comprising a portion of what is frequently lumped under the heading of "oncost." This charge, that can be put against the machine, will vary according to its initial cost and the room it occupies in the shop, and it may range from a few pence per hour for a small cheap machine, to several shillings per hour in the case of more important machines. Thus the effect of a reduced time by premium may cause direct saving of machine cost, and it will also make it possible to get more work from the machine, thereby obviating costly overtime or increasing the annual turnover.

A further item that is here suggested is, that with a given establishment and tool equipment, it becomes possible to get an increased output, and so perhaps converting a hazardous concern into a successful one.

There is still another matter to be observed by expediting the progress of

work through the shops, contracts may be filled more quickly, capital is locked up a shorter time in progress work, and items pass into the day-book at an earlier date.

With an effort to show what it means commercially, the author has prepared a series of diagrams showing the effect upon "oncost" under certain assumed average savings of time, and also the probable effect upon the profit and loss account.

Investigating the effect upon "oncost" and profit making, it becomes necessary to deal with *assumed* proportions of figures. For the sake of following some consistent form of reasoning, and while indicating generally the *probable effects*, the *actual results* will entirely depend upon the particular business to which the system might be applied. That his reasoning may be readily followed, the author has indicated upon Diagram 6 what he has assumed as composing that somewhat broad term "oncost," and that the information may be of some value, he has set it out in the form of percentages. Starting with an assumed normal output with a given plant prior to the introduction of premium system, and supposing that the effect of premium is to increase output, the diagram has been plotted to an ultimate increase of output of 100 per cent.

The first item considered as contributing to "oncost" is depreciation. This is usually placed at a certain percentage of the plant capital; therefore its line of representation will be horizontal, showing no increase. Probably it would be wisdom to allow an increased rate of depreciation to compensate for extra wear and tear upon machines.

The next item is works' management. This is assumed to increase by 10 per cent., to allow for the cost of time-setting department.

Commercial management is considered as likely to increase to the extent of 10 per cent.

The demand for fuel would not be directly proportionate to the output, and is placed at a 60-per-cent. increase.

Assuming that selling expenses would increase, allowance is made in the section of "oncost" placed under the general heading of trade expenses, to the extent of one-third.

Appendix C.

FILING CARD FOR TIMES AND RESULTS.

PREMIUM TIME CARD.

100, 103, and 105 Catalogue Number.
12 Engine Size.

Drawing No. 5631.

Description of Work Set of 3 cylinders.
Operation Planing.
On Machine Number 147.
Time allowed per piece 207 hours per set.
ditto for preparing Machine included.

Progress ticket No.	Quantity.	Per cent. Premium.	Time tak'n per piece.	Progress ticket No.	Quantity.	per cent. Premium.	Time tak'n per piece.
9315	set	18·7	150¾				
13773	do.	32·7	125				
15131	do.	35·1	121				

Appendix D.

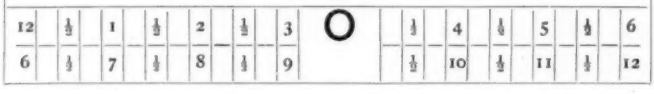
Progress Ticket as issued to a Workman.

FRONT:

Progress Ticket No. 17861.

Machine No. 203. Order No. 11037. Drawing No. 3549.
Day Man's No. 511. Name G. Brown. Rate of Wages_____
Night Man's No. _____ Name_____ Rate of Wages_____
Work 6 connecting rods. Size 3.
Process Slotting Complete.
Date given out 28/3/03.
Date Finished_____ Day Wages_____
Hours allowed 60 Night Wages_____
Hours Taken_____ Total Wages Cost_____
Machine Cost_____
Total Cost_____
Marker Off_____ Checker_____ Posted by_____

Browett, Lindley & Co., 1899, Ld. Starting Time: All entries on this Card to be made in Office.



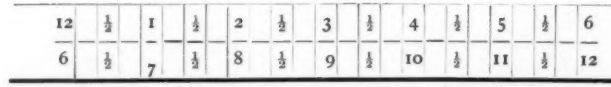
REVERSE:

Daily Time Spent on Job.

To be entered from ○ Time Sheets by Clerk.

Day Man.									Night Man.					
Date	No.	Hours	Date	No.	Hours	Date	No.	Hours	Date	No.	Hours			

Finishing Time.



NOTE:—Starting and finishing times punched in the squares provided to the nearest quarter of an hour, the shape of Punch indicating a.m. or p.m.

Appendix E.

COMPARISON OF PIECE-WORK AND PREMIUM COSTS.

Piece-Work Price.	Premium Cost.	Premium Balance Paid %	Piece-Work Price.	Premium Post.	Premium Balance Paid %	Piece-Work Price.	Premium Cost.	Premium Balance Paid %	Piece-Work Price.	Premium Cost.	Premium Balance Paid %
Each	Each		Each	Each		Each	Each		Each	Each	
19/–	10/2	20·9	25/–	16/2	29·3	4/11	4/4	19·8	4/6	3/9	35·2
7/4	3/10	20·9	2/–	–/9		5/–	3/3	25·0	25/–	17/–	33·0
8/6	4/9	29·0	1/8	1/–	13·4	7/8	5/6	23·2	1/1	–/8	30·1
1/2	–/6	27·2	3/–	1/3		1/5	1/–	16·1	25/–	16/8	25·6
–/10	–/3½		15/9	13/1	23·8	3/–	1/3	28·5	1/4	1/–	20·4
/6	–/5	23·1	8/–	7/7	18·1	3/11	3/5	24·2	·/5	·/4	26·0
–/6	–/6		20/–	15/10	21·6	4/–	3/–	6·8	–/8	–/6	
–/8	–/4½		2/11	1/9	18·8	4/·	3/7	12·4	–/8	·/6¾	
·/8	–/6	20·0	25/–	17/3	17·9	7/8	5/3		26/–	16/6	31·1
32/–	13/7	18·0	25/–	18/–	16·5	–/8	–/6	14·2	–/10	–/7	31·5
24/–	16/4	14·0	26/–	25/7	30·7	6/4	3/10	19·1	–/4	–/3	31·5
25/–	16/9	14·0	12/–	8/9	20·3	4/8	4/·		14/–	6/10	26·0
13/–	7/7	28·3	16/–	13/8	22·8	45/–	33/10	21·6	2/–	1/8	
7/6	4/11	23·5	11/6	10/7	23·1	1/1	–/9½	28·1	5/6	3/–	34·0
4/9	3/6	23·0	12/–	8/9	19·0	–/10	–/8	39·0	2/4	1/6	33·2
32/–	16/–	9·7	13/–	10/9	25·8	–/2	·/1¼		26/–	22/9	25·0
1/6	1/2	43·7	4/10	2/9	20·8	–/3	–/1		3/–	–/9	30·1
1/5	–/11	26·4	4/–	3/11		25/–	17/9	30·4	4/3	3/7	20·0
1/3	1/1½	24·0									

General shop labour would no doubt increase, by the extra amount of work to handle. This increase, however, will not be in direct proportion to output, as many types of labour, such as crane drivers, sweepers, etc., would remain normal. Thus, here the increase is placed at one-third.

The last item under the head of manufacturing charges would comprise many odd items, and it is difficult to say whether the increase would be proportionate. Probably it would not, yet for the sake of broadening the estimate, these charges are considered at double their normal.

Summing these up to a total, when the turnover is doubled, the probable increase of total "oncost" becomes 134 per cent. of the original, and for the sake of following the line of argument, it is assumed to have a proportional increase for lesser additions to turnover. As indicative of the comparison between "oncost" and output, an extra line is introduced into the diagram to show the "oncost" percentage decreasing in relation to sales as the turnover rises. It will be observed to drop 35 per cent. within the range included in the diagram.

In order to judge the probable effect upon profits, Diagram 7 has been prepared. Referring to Diagram 1, the total wage, including premium, if the whole plant is occupied, may be observed to rise as the manufacturing time is reduced per article, but to a lesser extent than the enlargement of output. This increase in the Rowan system is represented by a diagonal springing from zero. When the time upon the article is reduced to 50 per cent., the premium by both systems mounts to 50 per cent., and the output with the same producing plant, working full time, would be doubled.

In Diagram 7, the cost of production in wages plus premium is set out as with normal output, and as increased by the aid of the premium system. The productive wages are considered as normally amounting to 25 per cent. of the turnover. The material is assumed to be 30 per cent. of the turnover, and to increase in direct proportion. The "oncost" is considered to normally constitute 30 per cent. of the turnover, or 120 per cent.

Work. A set of three cylinders for a triple-expansion engine.
Process. Planing.
Machine. No. 147. Machine cost per hour 3/.

	Time Allowed	Time Taken	Hours Premium	% Balance	Total Wages and Balance	Total Machine Cost	Total Cost
					£ s. d.	£ s. d.	£ s. d.
1st	207	150¾	28½	18·7	5 18 2½	22 13 0	28 11 2½
2nd	207	125	41	32·7	5 9 7½	18 15 0	24 4 7½
3rd	207	121	42¾	35·1	5 8 5	18 3 0	23 11 5

Increase in man's balance 1st time from 18·7% to 32·7% = 14·0%
,, ,, 2nd ,, 18·7% to 35·1% = 16 4%
Saving in wages cost 1st time - - - - - = 7·7%
,, ,, 2nd time - - - - = 12·5%
Total saving in cost to firm 1st time £4 6s. 7d. - = 15·0%
,, ,, 2nd time £4 19s. 9½d. - = 17·5%

Work. Bedplate. Process. Planing.
Machine. No. 147. Machine cost per hour 3/-

	Time Allowed	Time Taken	Hours Premium	% Balance	Wages cost, and Balance	Total Machine Cost	Total Cost
					£ s. d.	£ s. d.	£ s. d.
1st	91	59½	15¾	26·5	2 9 8	8 18 6	11 8 2
2nd	91	54	18½	34	2 7 10	8 2 0	10 9 10
3rd	91	53	19	35·8	2 7 6	7 19 0	10 6 6

Increase in man's balance 1st time from 26·5% to 34·2% = 7·7%
,, ,, 2nd ,, 26·5% to 35·8% = 9·3%
Saving in wages cost 1st time . . . . . = 6·0%
,, ,, 2nd ,, ... = 7·1%
Saving in cost to firm 1st ,, ... = 8·1%
,, ,, 2nd ,, ... = 9·5%

of the productive wage. This latter percentage will, of course, vary with different establishments. The balance constituting profit is then placed at 15 per cent.

Allowing the various increases as discussed, and plotting the lines accordingly, enables us to see that the proportion of profit rises very rapidly as the turnover is increased by the aid of the premium system, and in spite of the high balances that become payable to the workers.

It will be observed that in the case of an establishment that nominally fails to make profit, although paying its way, an increase of production of 10 per cent. represents a profit sufficient to pay a dividend of 4 or 5 per cent.; whereas a 20-per cent. increase, which is not by any means difficult to obtain, so far as works' output is concerned, will represent a reasonable profit, with something to carry over.

To further illustrate this point, a small Diagram 8 is set out. It may be argued that these various diagrams and figures have been prepared, starting with the simple assumption that the introduction of the premium system is bound to be accompanied by a reduction in the producing time and the payment of substantial premiums to the workers. In response, it is merely necessary to quote from experience.

The author has found that reductions in time and cost have been more than expected, for it is by no means uncommon to find work costing as much as 30 per cent. less when worked by premium than it had hitherto cost by piecework.

As indicative of what can be done, the above instances are quoted.

These items were selected as being worked upon a planing machine where the cutting speed cannot be varied as in a lathe, and reduction in time can only be effected by increasing the cuts and in the handling.

Another planing job on an old machine progressed as follows:—

Under Piecework Cost 25/- Balance 25 per cent.
1st time under Premium System 17/9 ,, 30 ,,
2nd ,, ,, 17/2 ,, 33·3 ,,
3rd ,, ,, 16/8 ,, 45 ,,
4th ,, ,, 16/2 ,, 52 ,,

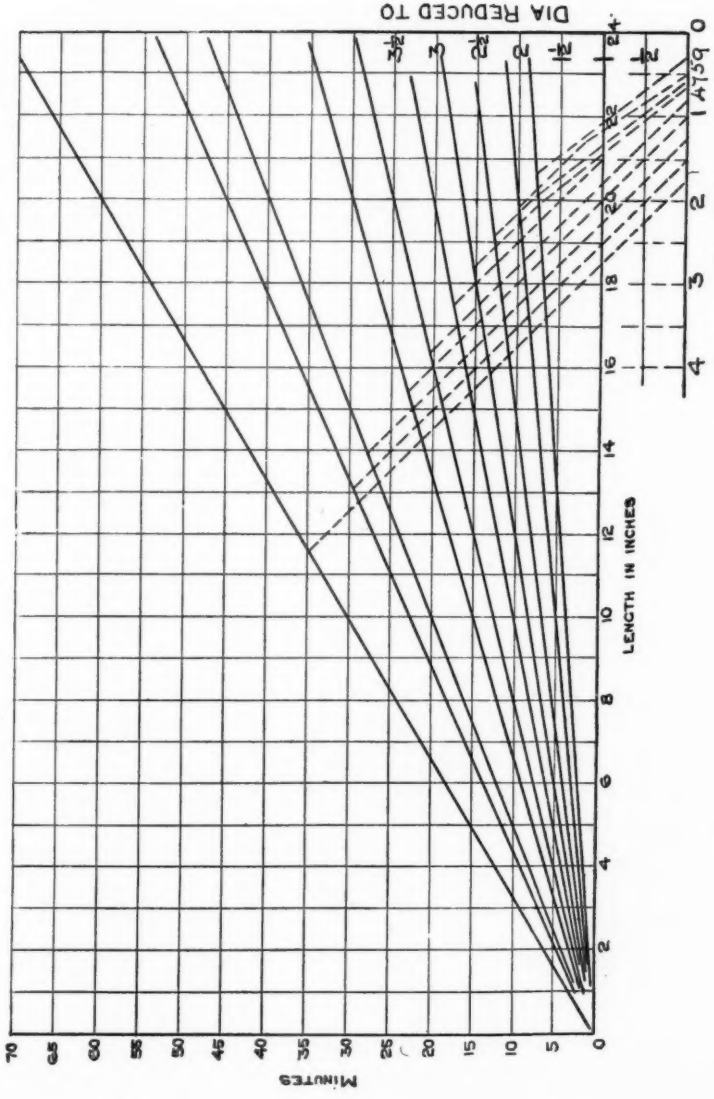


DIAGRAM 2.—REDUCING BAR IN TURRET LATHE (PROVED UP TO 2½-IN. DIA. BAR, ONLY ONE CUT)

NOTE.—Read diameter of Bar Stock on the lower right-hand of diagram, following ordinate until the diameter it is to be reduced to is reached. The dotted line immediately below then indicates the line of times to be used.

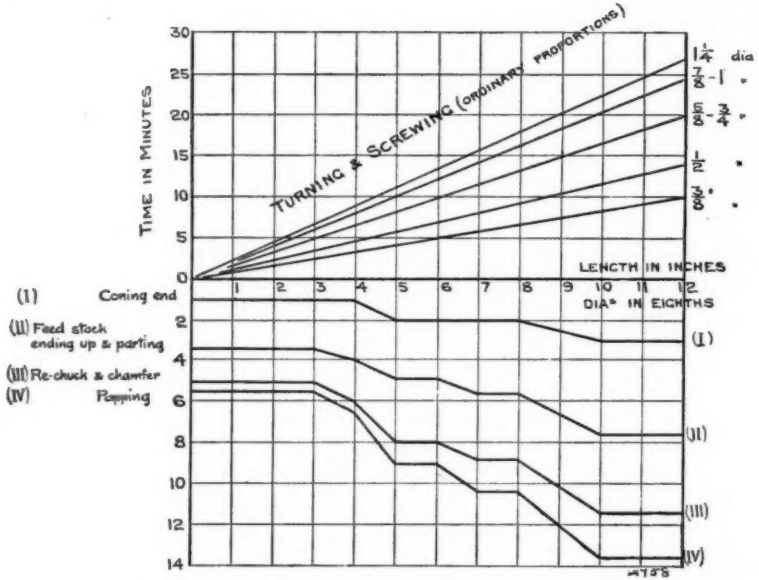


DIAGRAM 3.—TURNING BOLTS FROM HEXAGONAL BAR, "HERBERT" OR "J. L." LATHE.

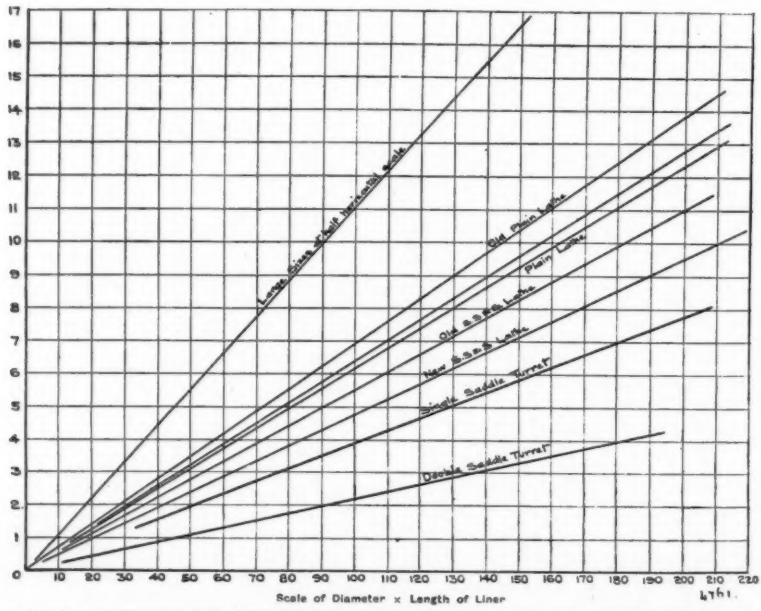


DIAGRAM 4 ILLUSTRATES HOW PREMIUM SYSTEM ACCENTUATES DEFECTIVE PLANT TURNING VALVE LINERS.

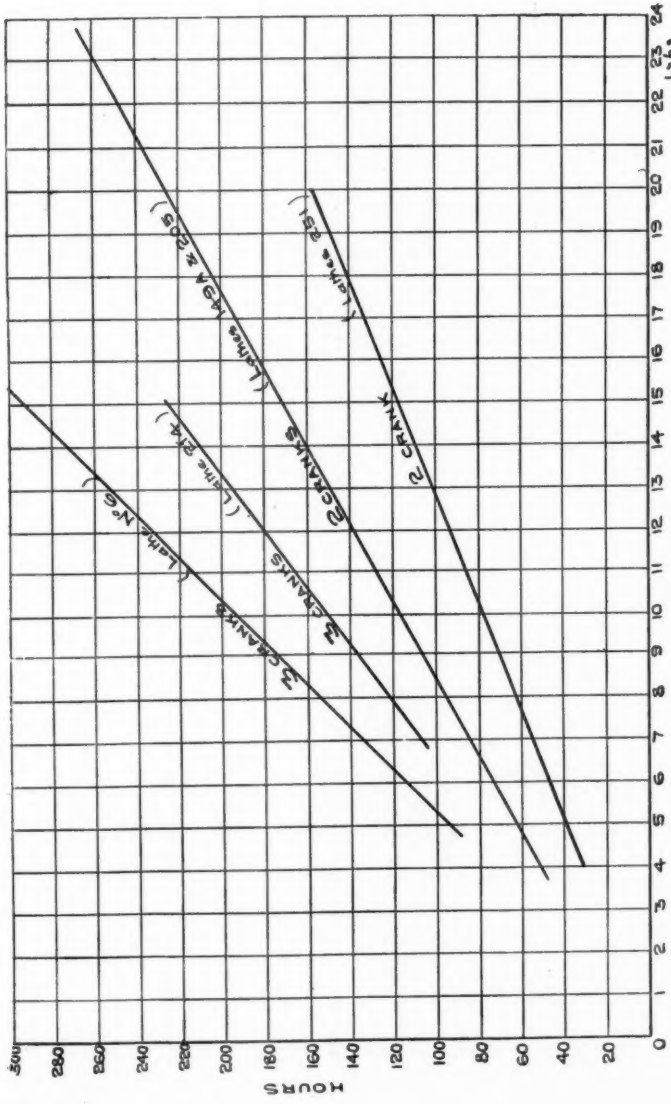


DIAGRAM 5.—TURNING CRANK-SHAFTS.

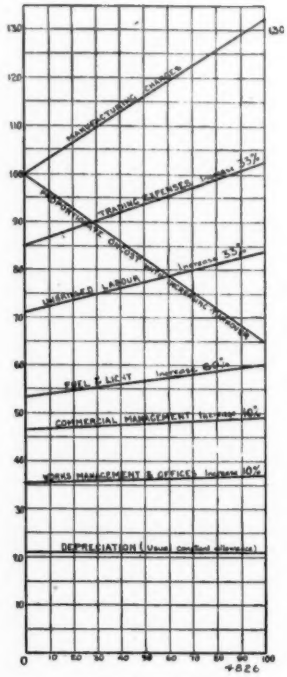


DIAGRAM 6.—ONCOST.

ONCOST WITH OUTPUT, ASSUMED INCREASED 100 PER CENT. BY THE AID OF THE PREMIUM SYSTEM.

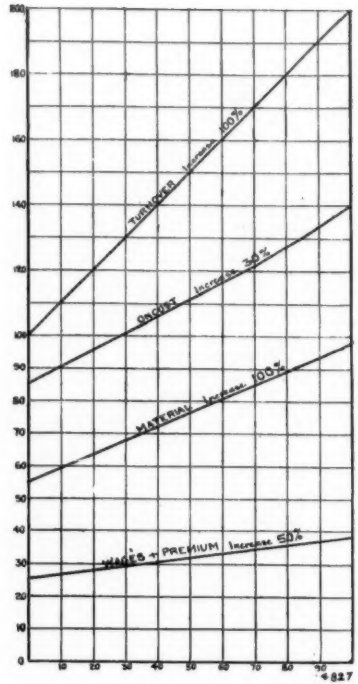


DIAGRAM 7.—TOTAL COST AGAINST TURNOVER. SCALE OF INCREASING TURNOVER IN PER CENT.

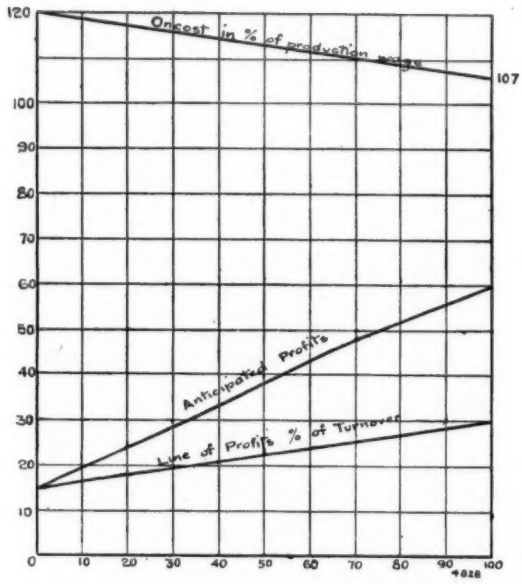


DIAGRAM 8.—ANTICIPATED PROFIT WITH INCREASED TURNOVER. ONCOST AS PROPORTION OF PRODUCING WAGE. SCALE OF INCREASING TURNOVER IN PER CENT.

As comparing the results of piece-work and the premium system as affecting costs, the author has prepared a sheet of results, showing at the same time the percentage premium paid to the worker (see Appendix E.). These jobs were done as nearly as could be ascertained on the same machine.

With a view of ascertaining whether the men are losers by the change, the author has summed the whole of the work done by premium at the works of the firm named, and finds that the average percentage of balance paid from the start is 20 per cent., while for seventeen consecutive weeks it has averaged 25·5 per cent.

The success of any scheme of remuneration or working depends largely upon those who administer it, and because it is successful in one place is no proof that it will be so at another. Even as in the case of piece-work, while it may produce satisfaction to both workers and employers at one place, it may, if not administered equitably and fairly, fail to come up to expectation at another. Honourable fulfilment of all agreements, especially regarding the standardised times, should be the keynote of its administration.

In conclusion, the author would respectfully submit to his fellow-members for their consideration, the thought that one of the most important principles of management is to create unity of interests between those whose help is needed, even in the most menial capacity, and the employer; and that this can best be done by instituting such a method of remuneration as is provided in the premium system.

Nile Irrigation Works.

By W. NOBLE TWELVETREES, M.I.Mech.E.

(Continued from page 312.)

II.—Upper Egypt. *(Continued.)*

IMMEDIATELY after the signature of the contract for the Nile Reservoir Works, in February, 1898, the contractors, Messrs. John Aird & Co., entered into possession of the site, and by the end of the year some thousands of native labourers and hundreds of Italian granite masons were at work. The actual permanent work done during the year 1898 was 28,532 cub. yds. of excavation on the east end of the dam and in the navigation channel. In 1899 excavation was completed for a length of 809 yds., and was in progress over a further length of 756 yds. The total quantity of work finished during the year was 133,616 cub. yds. of excavation, and 99,604 cub. yds. of masonry.

During the early part of the year it was decided to make preparations for building the foundations of the dam across the Cataract channels, and many plans were discussed by the Government engineers and the engineers representing the contractors, with the result that it was decided (1) to form temporary rubble dams, on the downstream side of the site, across the channels known as the Bab-el-Kebir, Bab-el-Haroun, and Bab-el-Soghaiyar, so as to minimise the force of the water, and thus to provide a comparatively quiet pool of water for the conduct of operations upstream; (2) during the following season to build sandbag dams, or "sadds," on the upstream and downstream sides of the site; and (3) to pump the bed of the river dry between the temporary dams. Those who know the Nile will readily realise that it might well seem to be an almost impossible task to construct temporary dams in the raging channels of the Cataract, to say nothing of laying masonry foundations to a depth of 40 ft. below the bed of the river.

For the formation of the temporary stone dams, granite rocks, varying in weight from one ton to four tons, were dropped one by one into the channels by the aid of cranes, but many of the largest stones were carried away by the force of the waters. In some cases several stones were tied together by wire netting and tipped in bodily; but whenever the mass moved after reaching the bottom the nets were cut and the stones escaped. The two channels first mentioned were closed without exceptional difficulty, but the Bab-el-Soghaiyar gave a good deal of trouble. Therefore the expedient was adopted of tipping in railway trucks, full of large stones, and bound round with wire ropes. Each truck with its load weighed about 25 tons, and acted as a toe against which large stones were afterwards successfully lodged, and at last the perseverance of the engineers was rewarded by the sight of the long-hoped-for dam above the surface of the waters. The three temporary dams were finished in July, 1899, to a level about 5 mètres below high Nile, and the flood subsequently passed over them without causing any injury. These dams were about 23 ft. wide on top, with slopes of 1 to 1, and the greatest depth was about 50 ft.

In the month of November the water level fell sufficiently to permit the commencement of the sandbag sadds, and the three channels mentioned were completely closed by the end of 1899. The chief measurements of the sadds were:—width on top, 16·4 ft.; greatest depth, 56 ft.; the slopes were at first 1½ to 1, but as sand and small pieces of stone had to be placed on the upstream side to staunch the sadds, the ultimate slope became 2 to 1. As the river was unusually low in the year of

FIG. 27.—ASWÂN DAM: ERECTION OF CAST-IRON SLUICE LININGS.
(From a Photograph taken June 19, 1901.)

which we are now writing, it was decided that the sadds should be continued across the central channel, and this operation was successfully completed by the middle of February, 1900, when the whole flow of the river was confined to the west channel. The effect was particularly satisfactory, as a considerable area was left dry, and the unwatering of the remainder proved to be a much easier task than had been anticipated. A large number of 12-in. centrifugal pumps was held in readiness so that ample power might be available in case the sadds failed to hold up; but fortunately the amount of leakage was very slight.

The Bab-el-Kebir was pumped dry by the aid of six 12-in. pumps in a single day, after which one pump working about quarter time sufficed to keep all leakage down. One 6-in. pump served to dry the Bab-el-Haroun, and two pumps of the same size performed the same service for the Bab-el-Soghaiyar. Excavation was therefore commenced in these channels by the end of January. On Feb. 28th, pumping was started in the central channel, the water being rapidly removed by one 12-in. pump, and all after leakage was kept down by one 8-in. pump. Taking full advantage of the abnormally low levels of the river in the year 1900, the contractors made enormous progress both on the line of the dam and in the navigation channel and locks, so that by the end of the season the foundations of the dam were built in all the channels of the river, with the exception of the large western channel; and out of a total length of 2,185 yds. the foundation masonry was laid for 1,990 yards. Unexpected difficulty was experienced in the deep channels, owing to the unsound character of the rock. In one channel the rotten rock extended 38 ft. below the level at which it had been assumed sound rock would be found. It has been pointed out on more than one occasion by Sir William Willcocks that the alignment chosen by

him for the dam, followed the line of soundest rock at the Aswân Cataract, and that the straight-line dam, insisted upon by the International Commission, was a mistake. He has also stated that the Commission overruled his objection that it was risky to expect sound rock on one long straight line in a material like granite, and that the decision of the Commission was confirmed by the Under-Secretary of State.

In this connection it ought to be observed that Sir Benjamin Baker admits that, after the alteration of alignment, neither time nor money were available for the clearly desirable preliminary of sinking shafts in the bed of the river to ascertain the real character of the rock. The formation proved to be particularly faulty in the Bab-el-Kebir and the Bab-el-Soghaiyar, and sound material was not reached until about the middle of May, 1900. In the central channel unsound rock was found in many places, so that masonry could not be laid before the first week of May; but matters were more satisfactory on Mohammed Ali Island. As non-completion of the foundation masonry on the unwatered area during that season would have necessitated the rebuilding of the sadds in the following year, great efforts were made to complete the programme mapped out. During the month of June work was carried on during weekdays and Sundays, and was continued through the night by the aid of electric lamps. Masons to the number of 353 were kept hard at work, and the total number of men em-

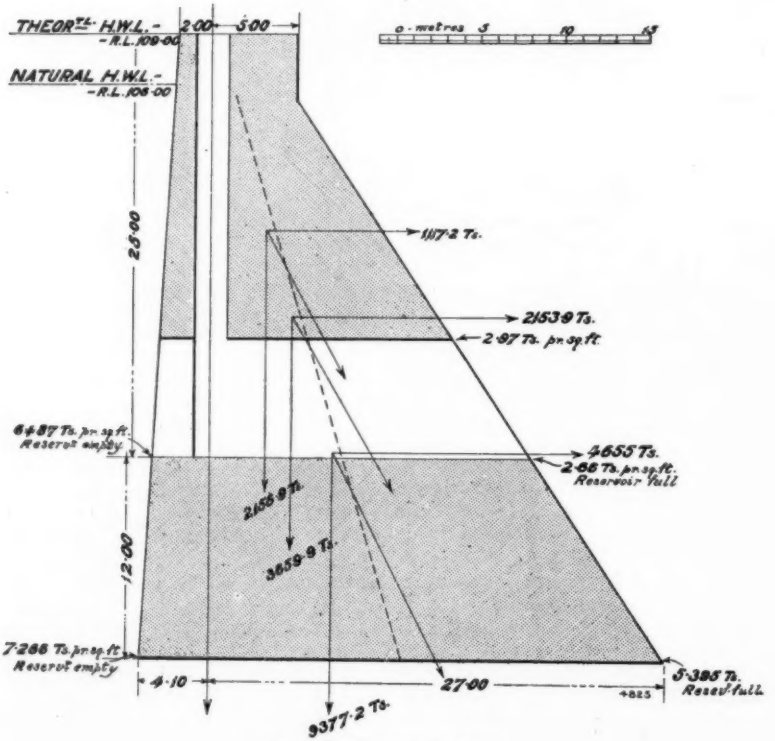


FIG. 28.—SECTION OF ASWÂN DAM.

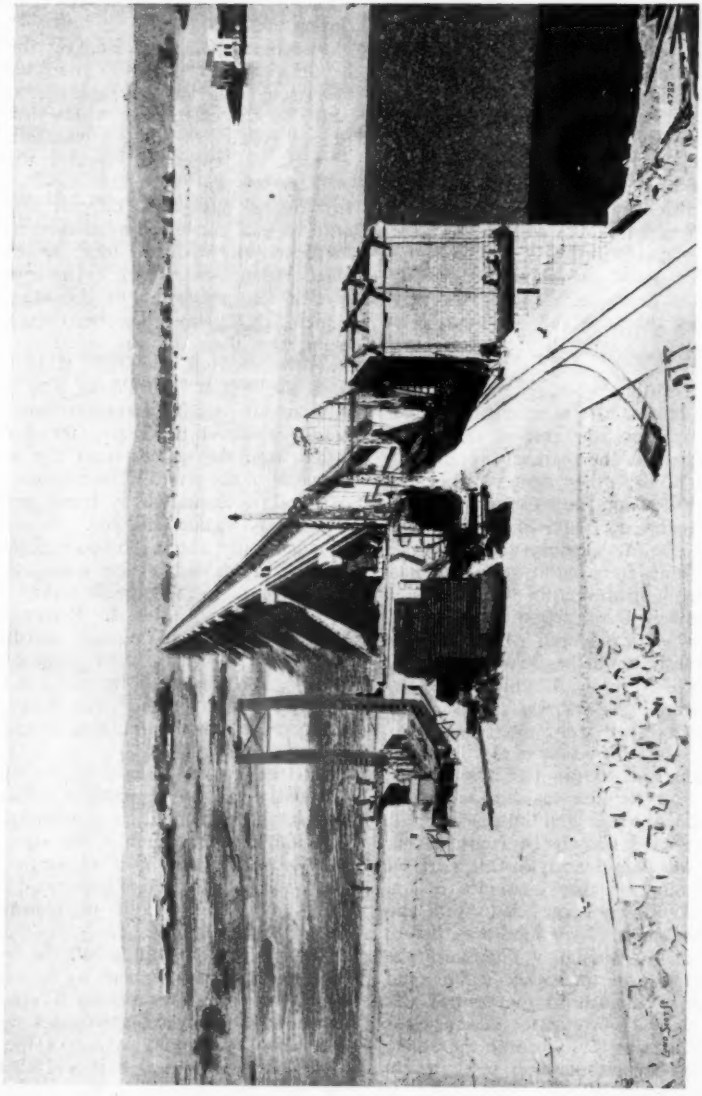


FIG. 29.—THE ASWÂN DAM: THE COMPLETED WORK.

ployed fell little short of 15,000. At the end of June night work was discontinued, for by that time it was evident that the required work could be finished in good time. On July 11th the sadd in the central channel was cut to relieve pressure on the other sadds, and at the end of the month these also were cut to permit the river to flow between the sluice piers. Work was afterwards continued until the rising flood reached the top of the masonry. On the subsidence of the flood masonry work was resumed, and preparations were made for closing the west channel, the only portion of the site where foundations remained to be made. During the year 1900 no less than 278,468 cub. yds. of excavation and 219,473 cub yds. of masonry were executed.

By the end of February, 1901, all the sadds for closing the west channel were finished, and on the 21st of the same month the bed of the channel was pumped dry. As in the other deep channels on the line of the dam, the rock was found to be considerably decomposed, and excavation had to be carried down to an average depth of about 19 ft. before solid rock was reached, while in the centre of the channel excavation had to be carried to a depth of some 25 ft. for a length of more than 250 ft. Masonry was begun on April 17th, and by May 18th the bottom was completely covered. Work was discontinued about the middle of July, when the sadds were cut. In the middle of April a sadd was commenced across half the central channel, in order that masonry might be proceeded with that had only been built up to R.L. 91 during the previous season. Masonry was commenced in this part on May 7th, and on the remainder of the dam similar work was pushed forward, the whole being raised above flood level before the end of the season. Therefore, the only portion of the work submerged during high Nile was in the central and western channels, where the masonry was purposely kept at R.L. 96, with the object of affording escape for water in the event of an exceptionally high flood, and of preventing inundation of the railways and buildings required for the work remaining to be done. Before the flood the whole of the foundations in the navigation locks were built, and the side walls were so far advanced that work could be continued during the flood.

In order to improve the river for navigation a channel, nearly 22 yds. wide, was cut through the narrow rapids north and south of the dam, these works involving the excavation of some 33,000 cub. yds. of rock. It appeared, however, that the velocity of the northern rapid would still render navigation difficult at times, and it was consequently determined to construct an auxiliary lock, which has since been completed. In order to give a free waterway to the sluices, a trench, 15 ft. wide, has been excavated along the dam on the upstream side, wherever the rock was found to be higher than the sills of the sluices, and on the downstream side excavation has been made, wherever necessary, for directing water from the sluices into the natural channels of the river. The amount of excavation necessitated by these auxiliary works was 80,000 cub. yds. At the end of 1901 only about 86,000 cub. yds. of masonry remained to be executed, and the ironwork in the capable hands of the sub-contractors, Messrs. Ransomes & Rapier, was in an equally satisfactory state. Fig. 27 is a photographic view showing the erection of the cast-iron sluice linings, which, together with other ironwork, were constructed and erected by this firm.

All the masonry was finally completed in June, 1902, twelve months before the appointed time, and the ironwork was finished in the autumn of the same year. The actual quantity of excavation was 824,000 cub. yds., and of masonry, 704,000 cub. yds. The weight of masonry is 149·5 lbs. per cub. ft.

When the reservoir is full the head of water on the dam is about 65 ft., exerting a pressure of 4 tons per sq. ft. upon the masonry. The resulting stresses are considerably lower than in any of the great dams hitherto built, and it will therefore be seen that, thanks to the severe conditions demanded by the International Commission, no difficulty of a structural nature will stand in the way

when the time comes for extending the Aswân dam to its full height. Fig. 28 is a section of the dam, showing the pressures at different points and under different conditions, and in Fig 29 is reproduced a recent photograph, which gives an excellent representation of the completed work viewed from one end.

At this point it will be appropriate to mention the services rendered by the engineering staff engaged upon the work.

In his last report, the Under-Secretary of State says that Mr. A. L. Webb, C.M.G., Director-General of Reservoirs, controlled the entire operations in a most able manner, and he also recognises the valuable services rendered by Mr. FitzMaurice, C.M.G., late Resident Engineer at Aswân, and now Engineer to the London County Council, and by Mr. Charles R. May, who has now been appointed Resident Engineer. The engineers representing the contractors, Mr. John Blue, of Messrs. Aird & Co., and Mr. Tabor, of Messrs. Ransomes & Rapier, also receive complimentary notice, while of Sir Benjamin Baker it is said that Egypt owes him a considerable debt for the exceptional services he has rendered as consulting engineer.

Having now dealt with the structural features of the Aswân dam, Mr. Twelvetrees will, in a supplementary article, make a brief inquiry as to the influence which it may be expected to exercise upon the conditions of water supply in Egypt.

A New Electric Signalling System.

SOME weeks ago we were invited, by arrangement with Mr. Sam Fay, the general manager of the Great Central Railway, to attend an exhibition of a new system of electric signalling, given at the entrance to the Woodhead Tunnel, Derbyshire.

The method, known as the Miller Signalling System, has been successfully tried on the Chicago and Eastern Illinois Railway, on a stretch of about 37 miles, and is there used as a complete and independent block system, adapted however to certain particular requirements of the case. It has more recently been adopted in the Park Avenue Tunnel, through which the New York Central and Hudson River Railway enters New York City. In this case, a most elaborate and complex system of signals had been installed on the electrically-controlled manual plan, and the new signals have been added to the existing arrangement without in any manner affecting the working.

The system, as arranged on the section of the Great Central Railway above-mentioned has also been modified to suit the local conditions, which are somewhat peculiar.

The Woodhead Tunnel is one of the longest in the kingdom, being 3 mls. 17 yds. in length, the distance between the two block cabins at either end being very considerable, and, in consequence, some time is generally lost, especially on the up journey. Several schemes have already been tried at this point, and a cabin situated half-way in the tunnel was at one time used during certain periods of the day. The installation at the time of our visit was, however, confined only to the length adjoining the western end of the tunnel, but providing that the working proves to be satisfactory it will, we understand, be extended to include the tunnel proper, a length particularly adapted for the operation of such a system.

The demonstration on the preliminary length can only be described as an unqualified success, the working of the apparatus on the track, and on the experimental coach and locomotive, taking place without a hitch.

By the Miller system, the indications are given to the engine-driver not by means of semaphores placed beside the track, but by lamps carried in the cab of the locomotive. Two small incandescent lamps, one white and the other red, are mounted side by side in the cab, and only one of them can glow at a time, the lighting up being actuated automatically by means of an electric-track circuit. When the train enters a block, one of the lamps lights up, and remains so until the beginning of the next block is reached; and if the line is clear for two blocks ahead, then the white lamp lights up when the train reaches a block point. If, however, either of the two blocks is occupied the red lamp lights up.

The working of the apparatus for effecting this can best be understood by referring to Fig. 1, which shows the general type form arrangement of instruments and circuits.

A and *B* are two consecutive block stations, the instruments in both being precisely similar. A magnet *d* has its coil connected across the rails at the rear end of the block, and when that block is clear the current from the track circuit energises the magnet. The magnet has two armature contacts: one of these, *f*, communicates with the preceding block station through the line wire and rail, by way of *m*, *h*, and *n*; the other contact, *e*, communicates with the succeeding block station, by way of line wire and rail, through the coils of a second magnet, *g*. This latter has an armature *h*, which acts

as a reversing switch for battery *j*, and connects this battery with the points *n* and *m* of the rail, on opposite sides of an insulated joint. When armature *h* is attracted, as it is represented in Fig. 1, then the current from *j* tends to flow in the rail from point *m* to point *n*; when *h* is dropped the current tends to flow from point *n* to point *m*.

The operation of the relay instrument and its circuits may now be readily followed out. When the track *AB* is clear, then magnet *d* is energised by track battery *c*, and attracts its armature. Similarly, when block *BC* is clear, magnet *d'* at *B* attracts its armature. There is then an electric circuit as shown from battery *j'* at *B*, through *h'* and wire *m'*, through lever *f'* back to instrument *A*, energising magnet *g*, and back through rail *AB*. Armature *h* is then attracted, and a difference of potential is set up from point *m* to point *n*. When either *AB* or *BC* is occupied, then the circuit through the coils of *g* is broken at *e* or at *f'* respectively, and armature *h* drops, so that battery *j* tends to send its current from *n* to *m* through the rail. This pressure between *n* and *m* is utilised by the locomotive equipment to give a signal in the engine-cab when the engine crosses the joint between *n* and *m*.

The engine equipment may have several different forms, one of which is shown above the track in Fig. 1. One axle each of engine and tender, *k* and *l*, are insulated from each other, and are connected through the coils of two magnets, *p* and *q*. The armature which plays between the poles of these magnets is adapted to make contact at *s* or *t*, completing the circuit of a battery *u* through the white lamp or the red lamp respectively. When the engine crosses the insulating joint above referred to, the pressure between *n* and *m* causes a current to flow through the coils of magnets *p* and *q*, and the direction of the current determines whether the armature is attracted up or down, to light the white or the red lamp. When the current flows from *k* to *l*, then the armature is attracted downward, lighting the red lamp and indicating that either block *AB* or block *BC* is occupied. When both blocks are clear the battery *j* sends current from *m* to *n* or by way of axle *l* to *k*, so that the armature is attracted upward and the white lamp lights up.

It will be noticed that a small battery, *r*, is arranged on the engine for a local circuit through the coil of magnet *q* in such a way that no polarised armature is required, while at the same time the battery *r* acts to hold the armature in place, either up or down, while passing through the block. When an insulated joint is reached, the circuit of *r* through magnet *p*, by way of the rail back to *l*, is broken, and magnet *q* being still energised, the armature drops and lights the red lamp. Thus the engine always gets a red signal the moment it passes an insulating joint, unless at the same moment the

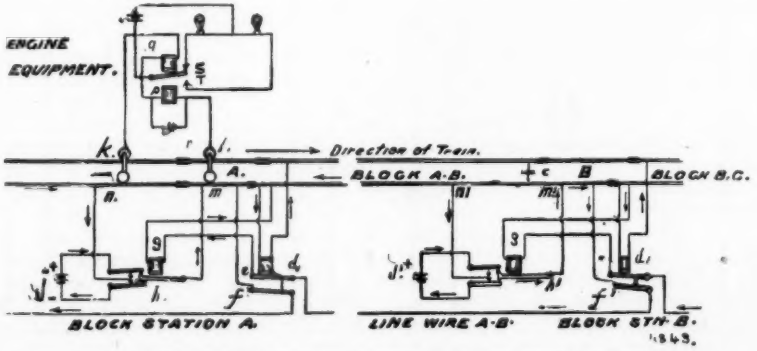


FIG. 1.—GENERAL TYPE FORM ARRANGEMENT OF INSTRUMENTS AND CIRCUITS.

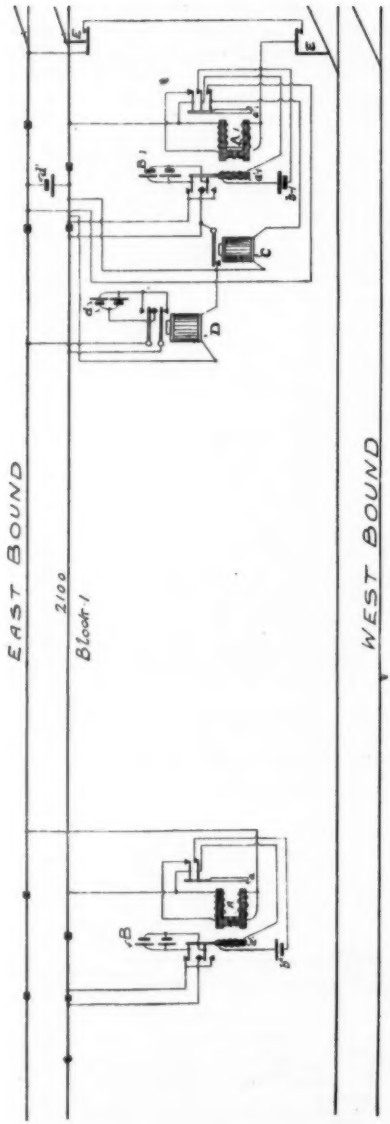


FIG. 2.

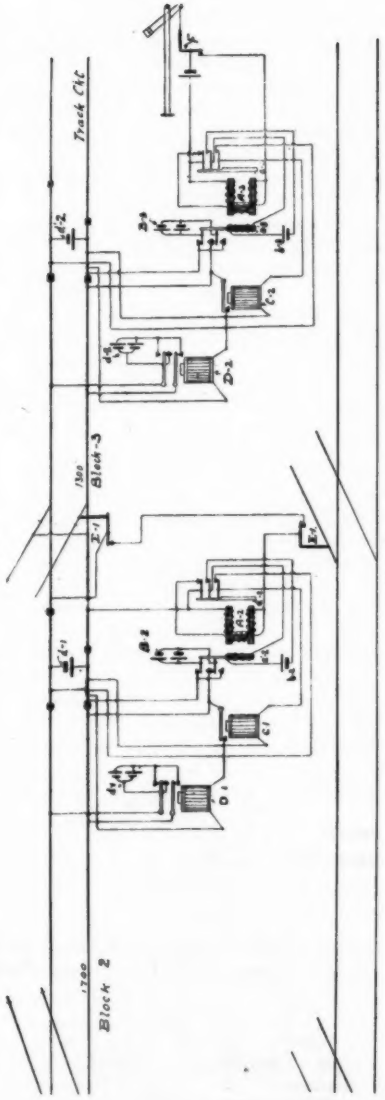


FIG. 2A.

FIGS. 2 AND 2A.—DETAILS OF THE INSTALLATION AT WOODHEAD.

"clear" impulse from the track relay operates to keep the white lamp alight. In order to avoid this action while crossing the insulating rail-joint at the rear end of block *AB*, this joint in the two rails is staggered longitudinally a distance of half a rail length, or at least a distance greater than the interval between axles *k* and *l*. As shown in Fig. 1, the stagger is less than this, the engine equipment being shown to exaggerated scale for the sake of clearness; properly, axles *k* and *l* should be shown a less distance apart than the stagger of the insulating rail-joints.

On the Chicago and Eastern Illinois Railway, the system is modified to the extent that no wires are used for connecting the different block points. The entire signalling information as to the condition of the two blocks ahead is conveyed by means of the track circuit alone, the track equipment consisting only of a single relay instrument, with a battery of cells at each block station, connected to the track rails. The Park Avenue tunnel installation, however, requires the use of line wires.

The details of the experimental installations at Woodhead, on the Great Central Railway, are clearly shown in Figs. 2 and 2A (Fig. 2A being a continuation of Fig. 2), from which it will be seen that the type system has again been varied.

A, *A*1, *A*2, *A*3 are track-circuit signal controlling relays, the coils of which are wound to 4 ohms resistance.

B, *B*1, *B*2, *B*3 are signal-giving gravity batteries, the two poles going to the main track rail; between them is placed an insulated track joint, and a similar joint is placed in the other track rail immediately opposite.

C, *C*1, *C*2 are auxiliary relays, controlled by batteries *d*, *d*1, and *d*2, the purpose of which is to protect the short rail sections necessary at each signal point.

D, *D*1, and *D*2 are pole-changing instruments, the coils of which are wound to 4 ohms resistance, and are energised by the signal batteries *B*, *B*1, *B*2, *B*3.

E, *E*, *E*1, and *E*1 are called switch instruments, which are attached to switch rods, and are simple circuit-opening devices, the purpose of which is to open the track circuit controlling instruments *A*, whenever it is necessary to so place the switch points that a car or engine would foul the main line.

F is a similar instrument to *E*, but in this case is attached to the tunnel starting-signal rod.

a, *a*1, *a*2, *a*3 are armatures to relays *A*, and are controlled by the track current that energises those instruments.

a', *a'*1, *a'*2 *a'*3, are also armatures attached to relays *A*, but the polarity of these is governed by separate batteries.

b, *b*1, *b*2, *b*3 are gravity batteries controlling the polarity of armatures *c*, *c*1, *c*2, *c*3.

d, *d*1, and *d*2 are track circuit gravity batteries, each composed of two cells in parallel, and are used to energise relays *A*.

d', *d'*1, *d'*2, seen between the tracks are gravity cells used to control auxiliary instruments, *C*, thereby protecting the short rail sections at signal points.

The east-bound track is the only one equipped. The distance from the first signal point on the left, to the second point, is 2,100 ft., the second 1,700 ft., the third 1,300 ft.

The operation of the track circuits is as follows (the direction of the trains being from left to right):—

A train on the first section would cut off the current from track relay *A*, both of whose armatures would fall back by gravity (being counter-weighted).

The current from battery *B* would now go to the main track reversed from its original direction; thus when met by a following engine equipped with the engine instrument, it would set that instrument to the "stop" position.

The first train passing on to the second section would cut off the current from track relay *A*1, at the second signalling point. The armatures of *A*1 would fall back, thus opening the circuit-controlling auxiliary instrument *C*, which in turn opens the circuit of pole changing instrument *D*. This reverses the track current on the first section, which now energises track relay *A*, bringing forward armature *a*, but not armature *a'*, thus retaining the

signal battery *B* in a position to give a "stop" signal.

The reason why armature *a* is attracted by this reversed current, and armature *a'* is not so attracted, is because in energising the coils of relay *A* the current is passing in the reverse direction, and the pole-pieces opposite to armature *a'* are now of the same polarity as the pole-pieces of armature *a'*, and repel instead of attracting.

The first train passing into Section 3 would cause similar actions on relay *A*, but in closing the points connected with armature *a*1 of that instrument the circuit-controlling auxiliary instrument *C* is closed, which in turn closes the circuit-controlling pole-changing instrument *D*. This in closing again reverses the battery on the track section in the rear, but this time in the proper direction, and in consequence both armatures of relay *A* are attracted, and the signal battery is placed in position to give a clear signal, two sections ahead being now clear, and so on throughout the sections equipped.

It will be seen that the track circuit of Section 2 passes through switch instruments *E* and *E*, on both east and west-bound tracks, also that the track circuit of Section 3 passes through switch instruments *E*1 and *E*1 of both tracks, so should either of these switch points be placed in a position to allow a train to enter the east-bound track, the two signalling points in the rear would be set in position to give a "stop" signal.

It will also be noticed that the battery-controlling relay *A*3 is connected to the fixed signal at the entrance of the tunnel, which, should it be on, would set the two signals in the rear to the "stop" indication.

Should it be deemed desirable at any time to connect up the line through the tunnel this circuit would be dropped down to the rails, thus giving the same indication.

As now set up, the starting signal at the tunnel only governs the track for 1,300 ft.; if desired, a slight change could

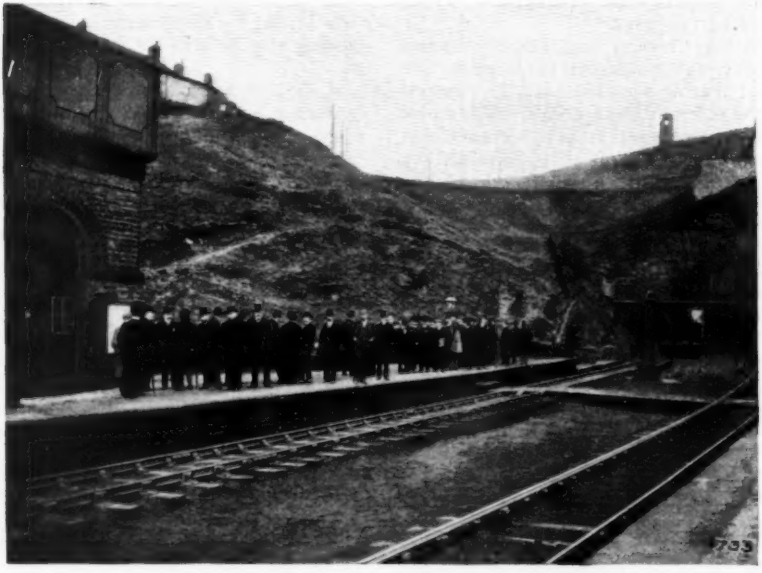


FIG. 3.—THE ENTRANCE TO WOODHEAD TUNNEL, GREAT CENTRAL RAILWAY.

be made which would enable it to govern the track for 3,000 ft.

If signal battery $B1$, $B2$, or $B3$ fail, the pole-changing coils will be de-energised, thereby setting the next signalling point in the rear to "danger"; obviously, should any other battery fail, the same condition would prevail.

In addition to placing the signal on the locomotive as herein explained, one could provide at signal points, if desired, an outside signal of such construction that, should two sections ahead be clear, that indication would be given; if the second section ahead were occupied, a caution signal would be displayed; if the first section ahead were occupied, a "stop" signal would be displayed. In case this outside signal is not desired, the customary fixed signals can be used to govern the movements of trains. In case the fixed signals are used to indicate a point at which the train must stop, then a careless clearing of a signal by a signalman would be checked by a danger signal on the locomotive, for the reason that the presence of a train on the track circuit would still be indicated two stations in the rear, no matter what the position of the fixed signal; at the same time, if the signalman found it necessary to stop an approaching train, he could give the stop indication on the locomotive by leaving his signals at danger.

During foggy weather the presence of fogmen would not be necessary, as the stop signal could be much more effectively given electrically, than by depending on the accuracy of cheap labour and a multitude of men, any one of whom might, by a moment of carelessness, cause a serious accident.

The insulated joints in the rails of the Woodhead equipment were made in the following way: A channel iron formed a sole-plate under the ends of the rails. Inside this was a layer of strong fibre insulation. This was protected mechanically from abrasion by two short iron plates, one under each rail end. In the sleeve so formed the ends of the running rail rested with a layer of insulation between them. The usual iron fish-plates were replaced by wooden blocks, which were bolted up by six bolts, three through each rail. The holes in the rail were bushed, so that the bolts should not make connection from the one rail to the other through the iron back plates, which strengthened these hardwood blocks. At points the insulation between the two moving tongues is obtained by an insulating coupling in the tie-rod. On the engine itself, instead of insulating two axles as mentioned above, the tender was insulated from the engine, so that when passing over an insulating joint the current from the engine to the tender, or *vice versâ*, should operate the lamp relays. The energy for lighting the signal lamps on the engine and also those which were placed in the saloon of the experimental train was obtained from a small dynamo, which was driven by a ½-h.p. steam turbine on the engine.

Fig. 3 gives a view of Woodhead Station and the tunnel entrance. The groups on the platform and at the tunnel face are those of railway officials and representatives of the leading technical journals and newspapers who attended the demonstration.

Judging by the tests witnessed at Woodhead, there would appear to be no doubt as to the suitability of the system for certain situations, particularly in hilly country and where curves are numerous, permitting the ordinary semaphor signals to be seen only with difficulty. As the system can be worked in conjunction with the existing signals, it should prove a very valuable adjunct in foggy weather.

The Mosely Commission.

OUR readers may probably remember that, owing to the liberality of Mr. A. Mosely, an opportunity was afforded last autumn for a number of officials representing various trades' unions to proceed upon a tour of investigation in the United States. The party, including Mr. Mosely and twenty-three delegates, constituted what is generally described as the "Mosely Industrial Commission," the object of the originator being that British workmen should be placed in a position to see, through their own representatives, the developments taking place in various departments of industry in the United States. Each of the delegates has written an independent report upon the things he was privileged to see during the course of his three months' visit to America, and the reports have now been issued in pamphlet form, with a preface by Mr. Mosely. Only four or five of the trades represented come directly within the scope of this magazine, and in the present article we have selected for special reference the report by Mr. George N. Barnes, Secretary of the Amalgamated Society of Engineers. A few words will suffice for the preface written by Mr. Mosely. In the first place, we feel it to be both a duty and a pleasure to acknowledge the patriotic and generous feelings which induced that gentleman to organise the Commission; and, in the next, we are bound to say that many of his remarks sound very much like an echo of the pessimistic wailings often emitted by some irresponsible journalists, who are totally ignorant of the engineering industry. For instance, the writer starts off with the amazing statement that the "true-born American" is in every way a better man than his "British brother." Then follows the suggestion that one reason why the American workman is better than the Britisher is that he has received a sounder and better education, whereby he has been more thoroughly fitted for the struggles of after life. We do not for a moment wish to undervalue education, which must always have an important influence upon the continued growth of national prosperity and progress, but other statements in the preface and the report tend to prove that the influence of education must necessarily be smaller in American than in British engineering shops. Mr. Mosely emphasises the up-to-date methods and equipment of American workshops. An essential feature of such establishments is the use of self-acting—and almost self-thinking—tools to such an extent and in such a way that the great majority of the men employed have nothing left but a wearisome, uninteresting task, for which neither education nor brains are wanted. What Mr. Barnes has to say upon this point is emphatic and noteworthy. Speaking of the American workman, he says: "He is confined to a ceaseless repetition of small operations, which leave no room for initiative or individuality; in short, he is in a deep and narrow groove, in which he cannot go wrong, and, so far as I had the opportunity of forming a judgment, he is just the timid invertebrate that might be expected as the outcome of such conditions." On the other hand, with British "old-fashioned" methods, often deprecated, practically all the men must be skilled and must use both education and brains throughout the whole day's work. This aspect of the education question appears to have escaped Mr. Mosely. Neither general nor technical education can materially assist a man in minding an automatic machine tool, which is fairly well able to look after itself. But, quite apart from all such considerations. we are not by any means convinced that superiority is a natural attribute of the "true-born American." Neither are we satisfied that British manufacturers are in the parlous state suggested by Mr. Mosely.

The conditions in this country and in the United States are by no means the same, and what suits one country will not necessarily suit the other. In the present day we are in a stage of transition. Consequently, manufacturers are adapting themselves to altered and altering circumstances. That they have not made any panic-stricken attempt to adopt wholesale everything that is found, or thought, best by Americans is only another proof of their sanity, and should justify confidence in their business ability and judgment. Some methods followed and some machinery used in the United States have already found favour in Great Britain, not because they are of American origin, but because, in themselves, they are suitable for adoption. In a similar way, our American friends have always made and continue to make use of ideas and practice originating in this country. Here and there, Mr. Mosely's laudatory ode on American excellence is punctuated by lucid intervals, in which some sound views are expressed with regard to the advantages workmen may derive from improved machinery, and to the desirability of drawing capital and labour closer together by ties of common interest. Taking it as a whole, the preface says too much, and does not say it particularly well. We therefore turn without regret and with some hopeful anticipation to the report made by Mr. Barnes. That gentleman is one of a comparatively new class, whose professional status is popularly believed to imply a rooted objection to progress in the form of improved tools and methods of manufacture, except such as may be expected to increase wages while at the same time reducing hours of work and minimising output. Whether such a belief be correct or not, we need not stop to inquire, for the impressions made upon a labour leader by American engineering institutions are sufficient to engage interest in themselves. The main portion of the report is of descriptive character, and in it Mr. Barnes gives a series of notes upon the various places he visited, both in Canada and the United States. His descriptions do not add much to general knowledge, as records of very similar character are the result of almost every visit to America, and a good many other people have written accounts of the same kind within recent years. What we are more particularly concerned with is to find what impressions were produced, and whether they are likely to be of service in leading British workmen in the right direction. From some remarks near the end of the report, we are glad to learn that Mr. Barnes is not inclined to take a pessimistic view of the British engineering industry. He very properly comes to the conclusion that the increase of American exports is merely one result of an increased world's demand, which has gone more largely to countries still in the first flush and bound of industrial expansion, than to established countries like our own. From the point of view of quality, he is convinced that British goods have nothing to fear, provided designers are encouraged. What this qualification may be meant to imply is a little uncertain. Mr. Barnes seems to entertain a pious hope that American workmen will some day begin to find out that they work too many hours a day to enable them to enjoy "the pleasures and amenities of life, and to attend to communal needs, in regard to which they are far behind us." Although the laudable zeal of a trades-union official is here evidenced, the fact is that the social condition of the American workman does not strike Mr. Barnes as being so enviable as some people wish us to believe. It is highly encouraging to find Mr. Barnes expressing the belief that American practice may be copied with advantage as regards the encouragement of inventiveness, and in the full utilisation of machinery. To the enlightened mechanic of the future, it will seem almost incredible that his predecessors could ever have entertained a conscientious objection to labour-saving machines and tools. By his recent renunciation of so ancient a fallacy, Mr. Barnes has taken an important step in the right direction.

As a sort of appendix to the report, answers are given to a series of forty-one questions submitted to the delegates. Space will not permit reference to

more than a few of the most important of these. Upon the question of piece-work, Mr. Barnes thinks that American employers do not cut down prices so much as is practised here, because there is more general recognition of the value of increased output. Premium and bonus systems, he says, are in the experimental stage in the United States as well as here, and in his opinion they have worked fairly well both for employer and employed. Mr. Barnes' views as to the general characteristics of the American workman, and the social conditions attending his working and domestic life, may be thus summarised: He welcomes labour-saving machines and up-to-date appliances, he places no restriction upon the number of machines that may be tended by one man, he is more readily rewarded by increased wages for personal energy and initiation. So far as mechanics are concerned, it is said that the "American workman" is to a very large extent the "English workman." His needs in matters of workshop sanitation, ventilation, and comfort generally are no better provided for in America than in this country. He eats too much, but is abstemious in the consumption of spirituous liquors; he is clothed no better than the British workman, he saves money, usually owns the house he lives in, and lives a comparatively short life. Finally, with the exception of money and continuation schools for his children, the general conditions of the workman in America are thought by Mr. Barnes to be in every respect worse than in Great Britain. Of course these views are merely the result of a few weeks' visit to a very large country, and must be taken with some reservation; but that the picture is correct in many respects there need be no reasonable doubt. The American workman does not live the gilded life so frequently depicted by those who are anxious to prove that everything is badly ordered in Great Britain. In some respects American workshops are said to be better equipped than the British, the difference being chiefly that a greater variety of special tools is provided for special work. The fact is, that owing to the immense demand for certain productions and to the system of splitting up trades among various specialists, the American engineer is able very frequently to manufacture things in very large quantities, and so can afford to lay down special plant. The same practice prevails here, though not to the same extent, partly because it would not always suit the conditions of trade and partly because we still await standardisation on an universal scale. Mr. Barnes says that American factories certainly do not turn out better work than our own; and he adds that the material is softer and less durable than that used in Great Britain. In order to have proof on the latter point he procured a sample of metal from the American shop of a firm of engineers having workshops in this country, and he had it tested, together with a sample from the British shops of the same firm, both being from the class of metal used for identical purposes in each country. This test is somewhat favourable to America, inasmuch as the firm in question is one of the best in that country. Nevertheless the report, which was made by Messrs. Stanger & Blount, of Westminster, shows the British steel to possess higher tensile strength. It was also shown on analysis to have more combined carbon and less silicon, and is therefore harder than the American sample of steel.

Finally, we will refer to the question as to whether there are any points in American practice that ought to be initiated in British engineering works. In reply, Mr. Barnes suggests (a) a freer use of machinery and latest appliances, (b) a more ready recognition and liberal reward on the part of employers of ability or initiative of the workman, by bonuses or otherwise, (c) the standardisation of work where possible, (d) the re-modelling of the Patent Law and Patent Office, (e) the provision of secondary or continuation schools. Patent Laws and secondary education are clearly important matters which indirectly affect workshop practice, but they form no part of it, while standardisation is practically a national matter that cannot be effected by any individual firm. Omitting these, we are left with only two suggestions for future guidance—(1) that more machinery

should be employed, and (2) that men should be paid according to merit. These two principles are precisely what British manufacturers have been fighting tooth-and-nail with the trades' unions for generations past. Up to the present the unions have refused to admit the morality of either doctrine. Like other labour leaders, Mr. Barnes comes back from America with an experience which is the antithesis of that attributed to Cæsar. He has been to America, he has seen, and is conquered. He comes back with a message to the workers of this country to abandon unreasoning prejudice against progress, and to work like men—intelligent men—for their own good, and the good of the country. The wisdom of this advice is so self-evident, that ordinary people may well wonder why it could not have been recognised by Mr. Barnes without the aid of a prolonged visit to the United States. But it must be remembered that British workmen have spent fifty years amid the various developments of mechanical science without being enlightened on the same subjeet. The advantages to be derived from foreign travel are admittedly great, but we are inclined to believe that Mr. Barnes, an intelligent and educated man, knew very well many things about the advantages of machinery and personal effort that were not supposed to be known by the Secretary of the Amalgamated Society of Engineers. However this may be, we now have a report, possessing the character of a thoroughly conscientious document, which preaches wisdom to workmen, and which deserves to be widely read and carefully studied by all who are employed in British engineering works.

The Electrification of the Mersey Railway.

THE month preceding the issue of this number has been rendered illustrious by the fact that for the first time steam power has been displaced in favour of electricity in the working of an English railway.

The undertaking, although of great interest technically, has, however, attracted a great deal of attention, chiefly because such a revolutionary change is not without significance as to the direction which development is taking in the railway world, indicating as it does the final supersession of steam by electricity on all urban and suburban steam railways carrying a dense passenger traffic.

Not that other suburban steam-worked lines are subject to the same disadvantages that were attached to the Mersey Railway, with its smoky, dirty and depressing tunnel and carriages, and its unpleasant and unfavourable conditions of working; but electrification will be certain to provide, first, for the public, a much more frequent service of trains, faster and more comfortable travelling in well-lighted carriages, and purer air in tunnels; second, for the companies, a larger passenger traffic and greatly reduced working expenses. Certainly, so far as the Mersey undertaking is concerned, the new service is so great an improvement upon the old, and the contractors have done their work in so thorough and painstaking a manner that its future commercial prosperity is a foregone conclusion.

On reference to the sketch-map, it will be seen that the Mersey Railway affords, besides the steam ferry-boat service, the only means of communication between the largely populated towns situated on both sides of the River Mersey. The system, at present, comprises nearly five miles of double track, extending from the Central Low Level Station, Liverpool, which connects with the Central Station of the Cheshire lines, under the river to Birkenhead, where the terminus at Rock Ferry makes a junction with the London & North Western and Great Western Railways. Of the intermediate stations, James Street, Liverpool, forms a ready means of access to the terminus of the Lancashire and Yorkshire Railway; and James Street is in close proximity to the Overhead Railway. From Hamilton Square a branch line connects with the Wirral Company's line at Birkenhead Park, a line which in the near future we may hope to see following the example of the Mersey Company in the matter of electrification.

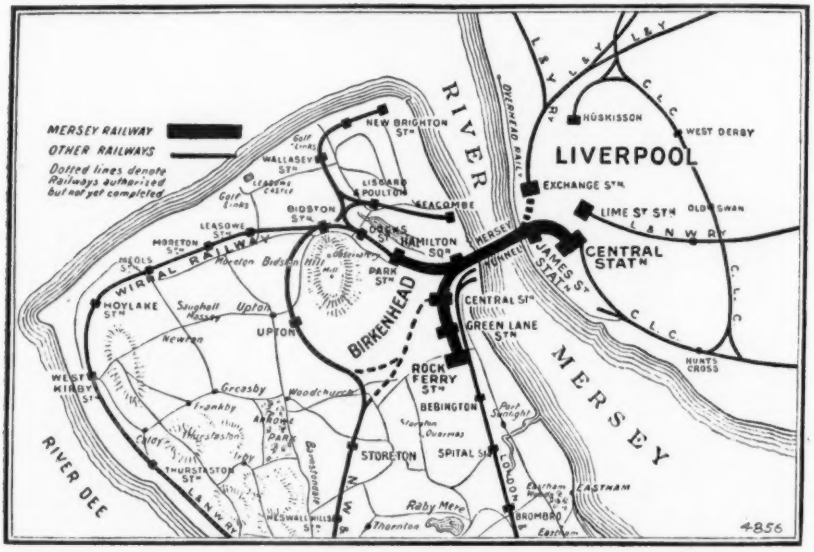
The inception of the railway took place in 1886 when an Act was passed granting the necessary powers for the construction of a pneumatic railway in the tunnel beneath the bed of the river Mersey. This scheme, however, did not appear to give satisfaction, with the result that it was abandoned until 1870, when plans for a steam railway were developed. Nine years later the actual work of construction was commenced by the boring of an experimental tunnel for the purpose of determining the nature of the subsoil.

Public confidence having been secured by this preliminary work, which was executed at a cost of £100,000, the capital required was readily subscribed, and in 1881 work was started on the construction of the permanent double railway line. In 1885, or just six years from the date of commencement, the work was completed. The cost of construction averaged £500,000 per mile, and no less than 320,000 cubic yards of rock were excavated from the main tunnel alone.

The official opening of the line by the then Prince of Wales took place on 20th January, 1896, a few days before the actual opening for traffic, and, with the exception of certain extensions and minor

improvements effected at various dates, the main features of the railway route remain substantially the same to the present day. The main tunnel is 26 ft. wide, and 19 ft. from the rail level to the crown of arch ; it is lined throughout with brickwork set in cement. There are also two auxiliary tunnels, consisting of the original experimental shaft, which is now used for ventilation purposes, and another used for draining the water away from the main tunnel. They are not independent.

The auxiliary and main tunnels are connected at frequent intervals by short cross drives, and a system of bulkheads in the ventilation heading makes it possible to draw the foul air from all parts, fresh air being drawn in through the stations and tunnel ends. Huge fans of 30 ft. and even 40 ft. diameter, driven by large horizontal steam engines, were employed for this purpose, occupying large fan houses situated where rent is exceedingly high, no small item of the



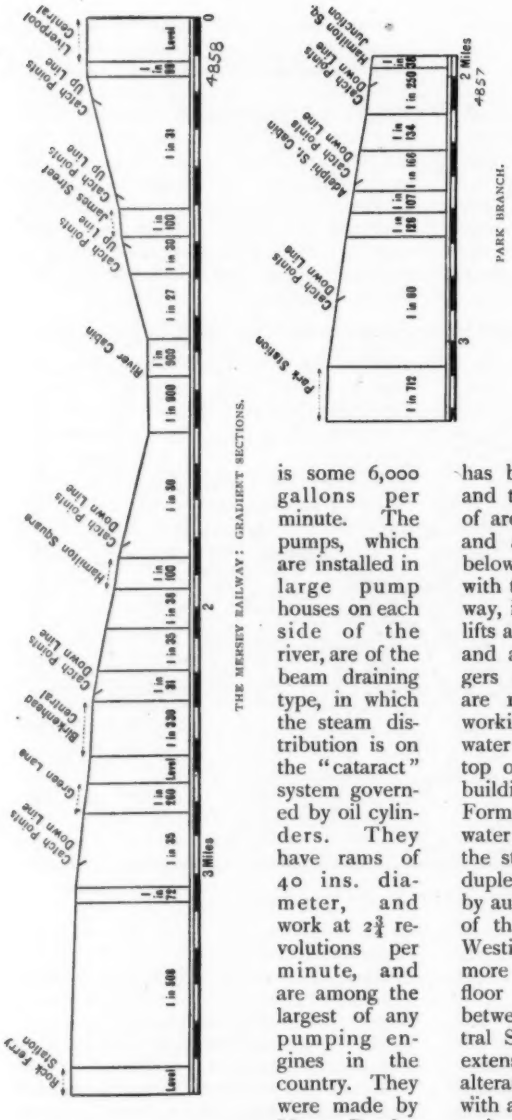
MAP OF THE MERSEY RAILWAY AND ITS CONNECTIONS.

however, for the whole of their length, but join for some distance at somewhere about the centre of the cutting.

Below mid-stream the tunnels are practically at the same level, but at the shore ends the divergence is very considerable, due to the necessity of having to drain the water downwards from the centre, whereas the main tunnel follows a line which is lowest at the centre, but rises, however, towards the banks at gradients as steep as could be negotiated by steam locomotives.

company's income being due to the heavy expenses incurred in their upkeep. These cumbrous appliances are now replaced by smaller electrically-driven fans, which more effectively and economically perform the simplified work of ventilation.

The drainage system is very complete and on a large scale, having been designed for a capacity of 18,800 gallons per minute. As a matter of fact, the engineers allowed a very large factor of safety, for the estimated maximum was 7,000 to 8,000 gallons, while the quantity actually pumped

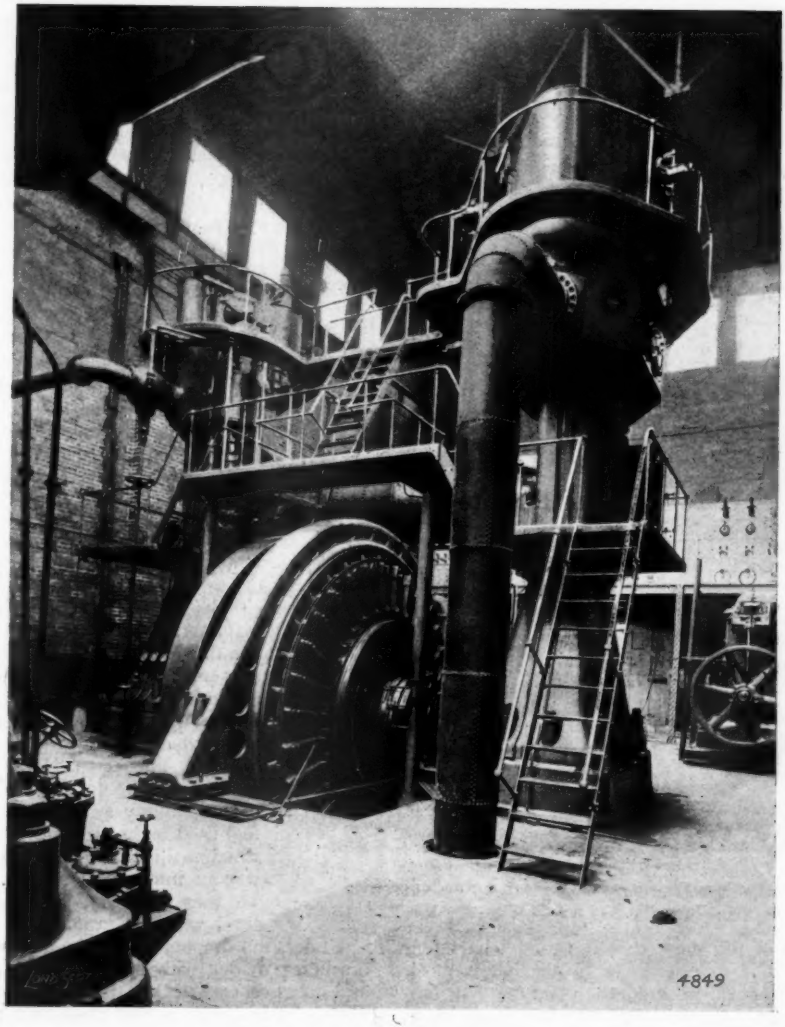


is some 6,000 gallons per minute. The pumps, which are installed in large pump houses on each side of the river, are of the beam draining type, in which the steam distribution is on the "cataract" system governed by oil cylinders. They have rams of 40 ins. diameter, and work at $2\frac{3}{4}$ revolutions per minute, and are among the largest of any pumping engines in the country. They were made by Messrs. Barclay & Co., Kilmarnock, and Messrs. Hathorn, Davey & Co., Leeds, and are so satisfactory that it is not proposed to replace them by others of a different type.

Of the great quantity of water dealt with only a small proportion comes from the main tunnel, as the brickwork and cement lining of this has proved itself waterproof to an admirable degree. The ventilation and drainage headings, however, are unlined almost throughout, and seem to have to some extent the effect of drawing water away from the main tunnel.

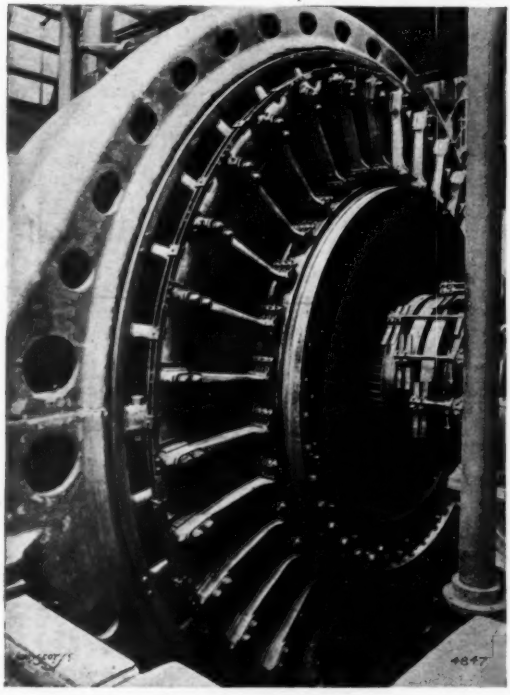
There are seven stations on the system, of which three are situated on the surface, two in tunnel, and one at the low level. In the case of the two tunnel stations—viz. Hamilton Square and James Street—the tunnel has been enlarged to a width of 50 ft., and to a height, from rail level to crown of arch, of 30 ft. They are 400 ft. long, and are situated at a depth of 100 ft. below street level, communication made with the road being in each case by stairway, incline, and hydraulic lifts. These lifts are perhaps the largest in the country, and are capable of carrying 150 passengers every journey. Their dimensions are $16\frac{1}{2}$ ft. by $19\frac{1}{2}$ ft., and power for working them is supplied by a head of water obtained from a tank built on the top of a tower rising above the station buildings to a total height of 130 ft. Formerly the pumps used for raising the water from an exhaust tank situated below the street level were of the steam-driven duplex type, but these have been replaced by automatically-controlled triplex pumps of the Simpson type, driven by 55-h.p. Westinghouse motors. They are much more efficient in service, and occupy less floor space. The opening of the length between James Street and Liverpool Central Station in 1892 completed the last extension to the line, although minor alterations have been made subsequently with a view to increasing the traffic, which, owing largely to the atmospheric condition of the tunnel, had been rapidly falling away while working expenses had been increasing.

Matters came to a climax three years



ONE OF THE 1,650-H.P. GENERATORS AT THE POWER STATION OF THE MERSEY RAILWAY.

ago, and as a consequence rights were obtained for electrical working, and in July, 1901, an arrangement was entered into with the British Westinghouse Electric and Manufacturing Company for the complete electrical equipment of the whole system. The work, which has been so successfully and energetically carried out by the contractors, can only be described as of the most thoroughgoing character, and is representative of all that is most advanced in modern practice. It has been executed without the least interference with the ordinary steam traffic, a circumstance which reflects great credit upon the Westinghouse Company when the difficulties of the situation—the bulk of the work having to be carried out in tunnel and under trying conditions—are taken into consideration.



COLLECTOR END OF DOUBLE-CURRENT ELECTRIC GENERATOR.

Taking the generation of the current as a starting-point, we will endeavour to give a description of the chief features of the new plant and equipment. The new electric power generating station is situated at Shore Road, Birkenhead, and closely adjoins the Hamilton Square station of the railway, and occupies the same site as the older pump-house connected with the tunnel drainage system. The buildings are of steel-work, bricked in, with substantial and neatly finished stone trimmings, and comprise the main building, battery-house, and fan-house. The main building, which accommodates the generating plant, measures internally, 135 ft. by 145 ft. 9 ins., and is divided by a substantial brick wall separating the boiler-room from the engine-room, the latter occupying about 70 ft. of the total length. Draught is secured by means of a brick smoke-stack of circular section, 13 ft. inside diameter, rising to a height of 250 ft. The site is admirably chosen, as it is fed by a branch of the Liverpool Docks railway system, by which every facility is afforded for the carriage of material and coal. It is, moreover, close to the centre of the railway system. The fuel used is Staffordshire coal, which is tipped direct from the wagons into a steel hopper of 10 tons capacity, which is level with the ground.

Under the hopper there is a 4-roll crusher, provided with 6-in. square shafts and massive cast-steel claws. The connecting gear-wheels are of steel, and the first shaft is driven with positive gear of the spur-wheel type by a $7\frac{1}{2}$-h.p. Westinghouse motor. All the wheels have cut teeth. From the crusher the now broken coal drops through a revolving filler, which

automatically feeds the buckets which pass underneath the same. Each bucket holds 56 lbs., and the working capacity of the conveyor is 50 tons per hour. The buckets being full pass round corner wheels; then horizontally to the face of the boiler-house wall, where they ascend to the top of the ash-hopper, which is built into the end of the building, so that on a sloping shoot being opened the stored ashes can be located to a truck which has just been relieved of coal. The tipper over the ash-tank is swung out of gear when coal is being handled. After passing over the ash tank the chains reach another set of cant-wheels, which work on a shaft running in bearings, to which are attached 1½-in. diameter square-threaded spindles, which are used for taking up the slack on the chain. From this point the run of the conveyor is vertical for about 10 ft., and after passing round another set of corner wheels travels over the large coal bunkers.

Near the far end of the building the conveyor makes a gradual descent to the wall, passes round the cant-wheels, then descends to the floor level, in which is cut a shallow trench. One feature of this plant which is worthy of notice is this section of conveyor under the firing-floor level. Owing to the rocky nature of the ground, it was found advisable to make the excavations as few and shallow as possible, and the designers (the New Conveyor Company, Ltd., of Birmingham) decided to dispense with the usual travelling filler for putting the ashes automatically into the buckets. To do this it was necessary to alter the shape of the buckets, so that only ⅛-in. clearance is found between them, and this enables the stokers to shovel the ashes through grids in the floor, and they thus find their way into the buckets without any spilling. When the buckets are filled they travel along in the trench to the railway end of the boiler-house, and just before reaching the end they pass down an incline, which brings them under the level of the crusher, which completes the cycle. To enable the ashes to pass round to the bunker previously mentioned, the coal filler is lifted out of gear. The driving gear is situated in the top left-hand corner of the boiler-house, and consists of a 15-h.p. completely enclosed standard type Westinghouse motor, which drives with positive gear on to the end shaft. The conveyor over the coal bunkers is carried by longitudinal joists resting on the roof principals, and on to these joists are attached the necessary brackets and rails.

The feed-water is drawn from the Birkenhead public supply, and passes through a Harris-Andersen softening plant to the economisers. The softening plant has a capacity for softening 3,000 gallons of feed-water per hour, and purifying 8,000 to 10,000 gallons of condenser water per hour. The economisers are by the Clay Cross company, the scrapers for these being operated by two multipolar 5-h.p. motors of the dust-proof type.

The vertical direct-acting pumps for feeding the boilers have been supplied by Messrs. G. & J. Weir, Ltd., Cathcart, Glasgow. These are of the twin-compound type, designed with a view of attaining a high degree of economy in the matter of steam consumption. There are two sets of pumps, each set consisting of two pumps of the well-known Weir type, connected in such a way that either pump may be used independently, or, as on ordinary service, the steam from the cylinder of the one pump may exhaust into the steam cylinder of the other pump. In addition to this the steam is used expansively in each steam cylinder, the object being to slow down the speed of the piston towards the end of the stroke.

The water cylinders of the pumps are 8 ins. diameter, with 12-in. high-pressure and 22-in. low-pressure cylinders, the stroke being 21 ins.

Each pump, when working under normal conditions of piston-speed and steam-pressure, is capable of delivering 170 gals. per minute, against a boiler-pressure of 170 lbs. per sq. in. when working non-condensing. The pumps are operated by steam superheated 120 degs. Fahr., and have an overloaded capacity, without excessive piston speed, of 50 per cent. above the normal.

The valve gear is positive—*i.e.* the steam valve can never be in such a posi-

VIEW OF AN INSULATOR SUPPORTING A CONDUCTOR RAIL. THE ILLUSTRATION ALSO SHOWS THE METHOD OF BONDING THE RAILS.

tion that the pump will not start immediately the steam is turned on.

The condensing plant contains surface condensers of the Weir marine type, and an interesting feature, as regards English practice at least, consists in the adoption of the Holly gravity return system, which, by a simple arrangement of drains and separators, ensures the economical and automatic return of condensed water to the boilers.*

The latter are at present nine in number, and are of the Stirling water-tube type, each having 4,370 sq. ft. of heating surface and working at a normal speed pressure of 170 lbs. per sq. in. Three of these boilers are at present engaged in supplying steam to the old pumping engines above-mentioned, and all are fed by means of Roney mechanical stokers driven by four standard Westinghouse steam engines of the 4½ ins. by 4 ins. size.

The main steam supply is from a ring header of 10 ins. and 12 ins. diameter steel piping; the exhaust main is of riveted sheet steel pipe of from 32 ins. to 48 ins. diameter. These mains are laid in the lower floor of the engine-room part of the power-house, the engines and dynamos being above them on a steel and concrete floor.

The main electrical supply is generated by three sets, each consisting of a vertical cross-compound engine of 1,650 h.p. normal rating, direct-coupled to a Westinghouse double-current generator. The engines are of the Westinghouse-Corliss type, well known in central station practice. The cylinders are 30 ins. and 60 ins. diameter respectively, and the stroke is 48 ins.; the admission valves of the high-pressure cylinder are of the "poppet" type, all others being simple Corliss. Reheating receivers are connected to the engines. The normal speed is 94 revolutions per minute, and with steam at 170 lbs. and 25 ins. vacuum, have an overload capacity of 60 per cent., or when working non-condensing, 40 per cent. The dynamo of each set is built direct on the shaft, between the high- and low-pressure sides of the engine. All these are exactly alike, and supply either direct current at a pressure of 650 volts, or three-phase alternate current of 25 periods per second frequency when running at normal speed.

The field consists of a vertically divided cast-steel ring having 32 pole-pieces cast on its inner side, projecting radially towards the centre. The pole-pieces are built up of soft steel stampings, reducing eddy-currents to a minimum. The fields are compound-wound, the circuits being over-compounded to give a rise of 10 per cent. in pressure of output with change of load from zero to maximum rated output. The armature is of the slotted core, drum-wound type; the core and commutator are built rigidly together on the one spider, which is pressed and keyed as one piece on to the engine shaft. The sheets of the core are stamped out in the form of segments having inner lugs, which dovetail into slots machined into the periphery of the cast-iron spider, the whole core being

* A drip receiver, placed below the lowest point to be drained, collects drips from all parts of the plant, from which it flows into a main receiver through a specially designed suction T. The forcing end of the T is connected to one or more separators, and this condensation is also delivered, under boiler pressure, into the main receiver. The whole is then swept up a riser pipe in finely-divided particles (due to a special discharge head on the main receiver) into an elevated separator, and from which it feeds by gravity into the boilers. The water in its upward flight is carried with the steam that is required to maintain the circulation, and occupies a vertical position, above the water-line of the boilers, in the return pipe, where the head of water, plus the pressure in the separator, forces it back to the boilers.

solidly clamped together by cast-steel end rings. The armature windings are of copper bar forged to final shape and insulated before being placed in the core slots.

No alternating current is being utilised at present; the only reason that provision has been made for it being the likelihood that certain other suburban railways in the district may ere long be converted to electric traction, in which case supply might be profitably obtained from the Mersey Railway power-house by means of high-tension alternate-current transmission and local sub stations. Two of the sets are at present in use to supply the ordinary load, although on the opening day, owing to the heating of a high-pressure piston rod, one of the sets took the whole load for a short period.

For the lighting circuits of the whole system, including the power-station and the arc and incandescent lamps of the stations and their approaches, two smaller sets have been put down generating current at the same pressure as the main dynamos, viz. 650 volts, thus rendering them a valuable adjunct for the traction circuits in case of need. Each set consists of a Westinghouse compound engine of the 16 ins. by 27 ins. by 16 ins. size direct-coupled to a 200-kilowatt direct-current generator. The engines are of the single-acting enclosed type, having a single horizontal piston-valve fixed over the side-by-side pair of vertical cylinders. They run at a normal speed of 250 revolutions per minute. The dynamos are of the Westinghouse multipolar type, of similar design to the main set, excepting that they are built for delivering direct-current only.

The engine-room is further provided with a reversible motor-driven booster set working in conjunction with a storage battery. The latter, as before mentioned, is accommodated in a separate building, and consists of 320 cells type "R" chloride accumulators.

The main switchboard, of 19 panels, is erected on a gallery at one end of the engine-room, raised 12 ft. above the floor, and 18 ft. wide, allowing ample space both in front of and behind the board. It is of standard Westinghouse pattern, with the usual indicating and recording instruments, switches, etc., mounted upon white marble. The works lighting switchboards and many auxiliary boards are separate, being located in convenient parts of the works buildings. The lighting is effected by means of 210 volt incandescent lamps arranged in groups of three in series.

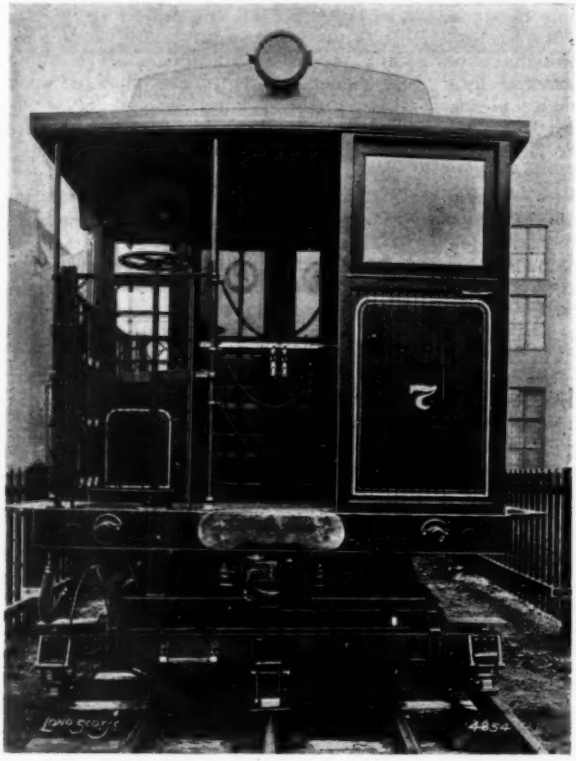
An overhead electric traveller has been provided, equipped with the usual dust-proof crane motors and controllers.

Coming now to the distribution, there are 19 main feeders of the lead-covered, paper-insulated B.I.W. type, which from the switchboard pass down one of the original vertical shafts to the track collector rails, which they reach through the cross-headings leading into the main tunnel. They are fastened to the solid rock by means of wrought-iron hook-racks firmly secured to the rock-face, where the shaft is horizontal, or by wrought-iron clamps in the vertical cuttings.

The track is fitted throughout on the third and fourth rail system, consisting of insulated feeder and insulated return conductors. The positive rail is on the outside of the track, and is the higher of the

COUPLING OF CONNECTION BETWEEN MOTOR CARS.

two. The negative rail is the lower, and is laid in the centre between the track rails. The insulators are of similar types for both positive and negative rails, and differ only in size. Each consists of a hollow cube of vitrified earthenware, on the top of which rests the flat base of the collector rail. The latter is held securely in position on each insulator by means of a pair of steel clips. The insulator block is carried on a broad based foot, which has a vertical centre-pin over which the earthenware cube is cemented with molten sulphur, the base being secured to the cross sleepers of the track by coach screws. The insulators are arranged at intervals of every third sleeper. The earthenware block of the positive rail insulator is a 6-in. cube, that of the negative rail insulator is 6 ins. square by 3 ins. deep. The positive rail throughout its whole length is prevented from accidental contacts or earthing by means of wooden guards. The bonding of the rails is done by means of flexible rail bonds of the "Protector" type. These are all one-piece bonds having flexible centres and solid ends, the solid ends being swelled by hydraulic pressure into holes in the rail web and sole. The web bonds are covered in and protected by the fish-plates. Each joint has two web bonds of 400,000 circular Mills section, and also two foot bonds of similar cross-section.



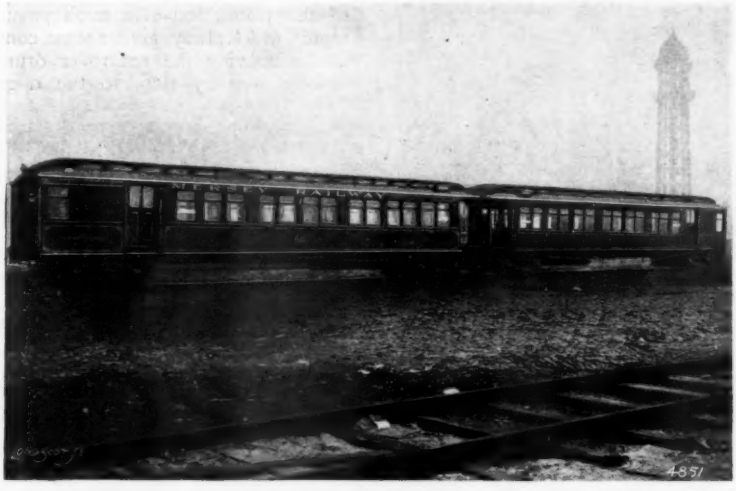
TRAILER END OF MOTOR CAR. THE VIEW SHOWS DISTINCTLY THE POSITIONS OF TRACK AND CONDUCTOR RAILS, ALSO THE CURRENT-COLLECTING SHOES.

Most of the conductor rails, which are of soft, high conductivity steel, are of 100 lbs. per yard, the remainder running at 60 lbs. per yard. They consist of 60-ft. lengths, and an expansion space has been left at every eighth joint in the tunnel and at every fourth in the open air.

The whole of the railway track has been relaid, and alterations of crossovers have been made where necessary on account of the clearance differences introduced by the new rolling stock as compared with the old, and the rearrangements required for the correct installation of the collector rails. A further reason was that every third sleeper required to be 3 ins. longer than the rest, to accom-

modate an insulator for the positive collector rail.

The running rails are in 30-ft. lengths, weighing 86 lbs. per yard, of double bull-head section; they rest on wooden cushions recessed into 54-lb. chairs, secured to cross sleepers spaced at from 13 to 16 per rail length. The ballasting consists of 6 ins. of clinker ash at the surface, below which is 4 ins. thickness of broken sandstone resting on a well-packed floor of sandstone blocks. The sandstone used is part of that cut out during the driving of the tunnel.

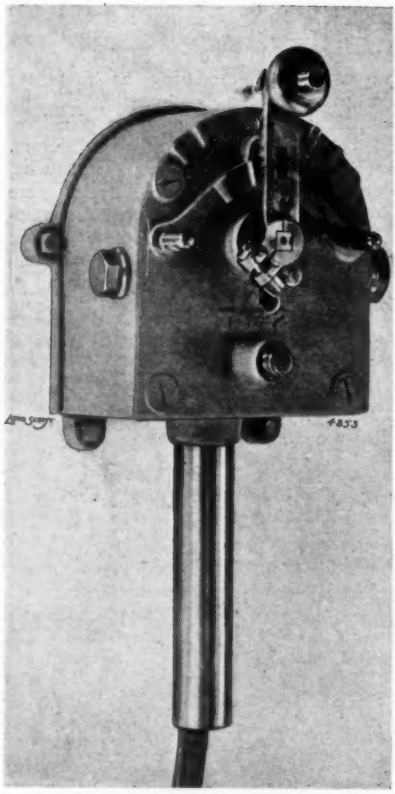


MERSEY RAILWAY: FIRST- AND THIRD-CLASS MOTOR CARRIAGES.

The electric train consists of two motor-cars, one at each end, with two or three trailers varied to suit the requirements of the traffic.

The present rolling stock consists of 24 motor-cars and 33 trailers, 12 of the motor-cars being first-class, and 12 third-class. The first-class cars will accommodate 48 passengers, and the third-class, 50. Behind the motorman's compartment accommodation has been made for passengers' luggage. Of the trailer cars, the first-class, of which there are 11, will accommodate 60 passengers each; and the third-class, of which there are 17, 64 passengers each. There are five composite cars, accommodating 22 first-class and 40 third-class passengers. All the cars are built on the corridor principle. The bodies have been supplied by Messrs. G. F. Milnes & Co., Hadley. The trucks, which are of the double type, were manufactured by the Baldwin Locomotive Works Co., Philadelphia. Each motor-car is provided with four Westinghouse No. 83 type railway motors, of 100 approximate h.p., working at from 550 to 600 volts, of the enclosed four-pole type.

The collector shoes are fitted on stout wooden beams, one beam being fixed to the touch frame at the end of every car, and carrying three collector shoes. Two of the latter act as current collectors, running alternately on the positive rail; the third shoe runs on the negative rail, forming the negative terminal of the car circuit. They are of soft iron, and gravity is depended on to maintain an efficient electrical contact.

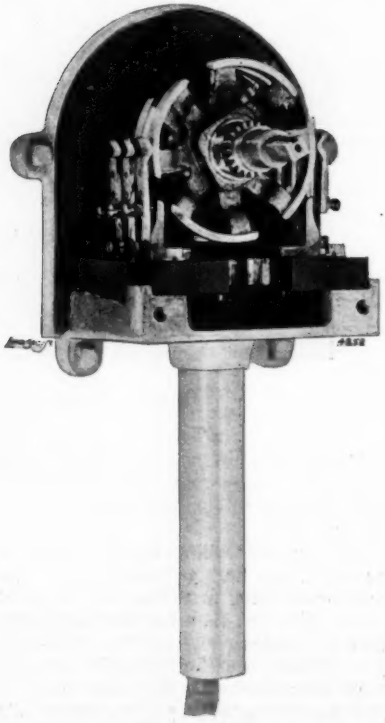


MOTOR-MAN'S SWITCH.

The controllers and the circuit-breakers are equipped with the Westinghouse electro-pneumatic system for train operation on the multiple-control system.

This is a method which has obtained a considerable vogue in America, and wide practice has proved it to be a complete success. By its means the motors can be controlled from any point distant from the motor, and a train having two or more motor cars in its length, can be controlled from the leading vehicle of the train. Two power agents are employed, viz. electricity and compressed air; the former being used for carrying the driver's wish through the train by reason of its rapidity of transmission, the latter for performing the actual working of the apparatus on account of its strong and reliable action.

The apparatus consists essentially of small compressed-air motors, which take the place of the driver's hand and actuate the controllers and circuit breakers. The two vertical shafts of the main-current controller are extended above the controller cover to receive the actuating gear, which replaces the usual hand levers. The projecting end of the shaft of the main drum of the controller is fitted with two ratchet wheels and a pinion wheel. The former serve for moving the controller "on." The pawls are carried on the end of the piston rod of a small pneumatic motor, which always gives a short complete stroke, moving the controller drum definitely, step by step, to the operating



INTERIOR OF SWITCH.

position required. In returning the controller to the "off" position, the pinion on the shaft is brought into use. This gears with a rack carried on the piston-rod of a long-stroke pneumatic cylinder, which also always makes a definite complete motion to the end of its stroke, when it is put into action. Thus the return to the "off" position is always complete. The reversing drum of the controller is also actuated by a rack-and-pinion gear and small pneumatic motors; the circuit-breaker also is opened or closed by electro-pneumatic motors.

The admission of compressed air to all these small motors is accomplished by means of small pin-valves electro-magnetically operated, the current being supplied by a small secondary battery. The driver controls the whole of the motor-car apparatus in the train by means of a multiple-control switch. Moving the switch handle over to the right or to the left causes the train to move in either one direction or the other. The first motion of the switch in either direction sends current through the corresponding valve magnets of the reversing gear of all the controllers, thus throwing their reversing drums to the positions corresponding to the required train direction.

Although the switch handle can be turned straight to any position, the car-controllers are not moved over simultaneously with it, but by means of an automatic repeating device they are turned step by step by the repeated backward and forward strokes of the short air-motor.

The step-by-step movement of the controllers tends to preserve the motors from sudden damaging over-loads; but they are further protected by an automatic device which arrests the motion of the controllers, should the main current reach a certain high pre-determined value. A reduction of the current releases this locking, and allows the controllers to continue their advance to the required operating position.

The compressed air supply for the controller and circuit-breaker operating gears is drawn from the Westinghouse air-brake reservoir beneath each motor car, which is charged every journey by a small electrically-driven automatically-controlled compressor plant installed at the terminal and several intermediate stations.

A connection between the air-brake operating cylinder and the releasing cylinder of the controller ensures the instant return of the controller to the "off" position, should the train brakes be applied when the motors are receiving current. It is well known that a break in the continuity of the pneumatic system of a train equipped with Westinghouse automatic brakes, caused either by a parting of the train or by any other accident, results at once in the brakes being applied over the whole train length. Such a failure or accident would, in a train fitted with the Westinghouse electro-pneumatic system of control, result in the instant cutting off of the driving current.

The motor-man's compartment contains the controller, but it is quite at one side and does not interfere with him in his correct working of the train-driving appliances. The driver occupies the left-hand side of the compartment, having as the only levers necessary for normal train operation the small lever of the air-brake valve and the handle of the multiple-control switch. These are placed not more than a foot apart, and are about waist high.

The other appliances within easy reach are the lever for actuating the automatic coupling with which the rolling stock is uniformly equipped and the hand-wheel connected with the usual type of hand-brake. Overhead is the main circuit-breaker of the motor's electrical supply. The whole of the compartment is lined with asbestos slate.

The automatic couplings used are of the Buhoup three-stem type. They are a combination of centre draw-bar coupling and single centre buffer, forming the only cushion buffer which is fitted on these carriages. The joining is automatic, by the forcing of two vehicles together; release is effected by means of the hand-lever and chain from the motorman's compartment, as already mentioned. Other devices which come under the control of the motorman are an air-blast track-sander and an alarm whistle, both of which are

actuated by compressed air drawn from the brake supply.

The seven-wire cable of the control system, as well as the train-pipe of the brake system, is carried along the left-hand side of the carriages under the floor, the connection of the power between carriages being simply effected by means of a seven-point plug and socket joint, protected by a light annealed iron housing.

The first-class cars have polished mahogany panels inside and spring rattan seats. The third-class cars are finished in light oak, with bentwood seats. Outside the cars are finished in a rich, dark red, which is relieved with gold lines. The seats are mostly arranged along the length of the carriage, the passengers facing the centre; and sliding glass panel doors are fitted between the compartments.

The first electric train was run over the new track on January 31st last, but since that date continuous experimental runnings have been maintained between the ordinary steam service and during the night.

The last steam train to carry passengers through the tunnel left Liverpool Central Station at 12.26 on Saturday, May 2nd, its departure being signalled by a brass band playing "Auld Lang Syne," and popular airs with refrains appropriate to the occasion, while the steam locomotive joined in the celebrations by discharging a salvo of detonators as it passed through the different stations on its final journey.

On the following day a party of directors and their friends made a tour of inspection over the line, and at mid-day the trains were thrown open for the accommodation of the public.

With regard to daily service, a three-minutes' service is now in operation between the Central Station, Liverpool, and Hamilton Square Station, Birkenhead, and a six-minutes' service from the Central Station, Liverpool, to the Park and Rock Ferry Stations. This represents a considerable acceleration of the recent service, and the schedule speed of twenty miles an hour, including stops, places the Mersey Railway, in spite of its steep gradients, in the position of being the fastest electric railway in this country.

[The Editor takes this opportunity of thanking the British Westinghouse Co., and Mr. R. Bowman Smith, the traffic manager, for the opportunity afforded him of inspecting the line, and Messrs. Kirker and C. A. Bustard for the courtesy extended to him on the occasion of his visit.]

WORKSHOP PRACTICE.

❀ ❀ ❀

REPLY TO E. C.

Building Commutator. *(Page 263.)*

To decide this matter, it is necessary to consider why a commutator requires heating. The general construction is, a cast-iron or steel sleeve with flanges at each end, turned conical, and drawn together by bolts. There is nothing in the mechanical construction to require the application of heat to assist the compressive force exerted by the bolts. The difficulty really arises with the insulating material between each section, and more particularly between the whole of the sections and the sleeve upon which they are mounted. These insulating cones are generally of mica in small pieces, cemented together and moulded to shape. The heating assists the exudation of superfluous cement, and the natural oil which is held by the mica strips between the adjacent segments. It should therefore be carried out after the commutator is completely assembled, and to a higher temperature than can possibly be attained in actual working. There is, of course, no objection to heating the parts separately, providing the application is continued after assembling, and during which time the nuts may be gradually tightened. J. H. H.

REPLY TO W. W.

Alterations in Dynamos. *(Page 263.)*

The method suggested for dealing with faulty field-coils is only applicable to motors having a two-circuit winding on the armature, which include all bipolar and many small multipolar motors. The full voltage would be thrown on the coil or coils remaining in circuit, resulting in increased shunt current and additional heating, which in a bipolar machine would probably be of a dangerous character. In multiple-circuit armatures, with one set of brushes per pole, disconnecting a faulty coil would decrease the flux in that and the two adjoining poles. If four poles, disconnecting the opposing magnet coil would permit the motor to run (with all brushes on) at a higher speed. With six poles no symmetrical arrangement can be arrived at, either by dispensing with coils, poles or brushes. J. H. H.

REPLY TO W. W.

Electricity Meters. *(Page 264.)*

W. W. starts his query with a statement as to the prevailing practice of installing meters which one hopes is not accurate, if only for the sake of the reputation for common-sense of the managers of supply companies. At any rate, the prevailing practice is at variance with the writer's experience, which is, that meters are removed and recalibrated after a use of, at most, three years. As the majority of meters become slower as time passes, it is evident that it is better economy to pull them out and recalibrate after, say, three years, than to leave them on circuit until they are only fit for the scrap-heap. In the latter case they would be probably from 10 per cent. to 20 per cent. slow, a percentage which is worth considering if the consumer's bill amounts to £20 per annum. But, taking the question as it stands, where meters are left on circuit for five to ten years, the best thing to do is to change the practice. Try instead a proper testing department, and get a good man to look after it. Then give him the old meters to put right, and he, if he has a good knowledge of electricity and a lot of experience with meters, will soon have them accurate within 2½ per cent. And this without calling upon the makers at all, except for a few spare parts. The above broadly answers W. W.'s question, but to give details as to the treatment necessary for the meters would involve the description of each type, and that would mean a good-sized volume. A simple cleaning, for instance, will do wonders for a Thomson meter, and with luck it can be put right in a quarter of an hour, but in obstinate cases it may take two hours. Clean mercury does a lot for Hookham and Ferranti meters, and the latter is often benefited by a heavy overload for a short time. To alter the rate of an aron, add or take from the shut resistance, but if the curve of the meter is bad it may be due to a thousand and one causes, and the best thing to do is to ask one of the firm's travelling inspectors to put it right. Other meters, other ways. G. C. C.

REPLY TO H. P.

Polish on Turned Work. *(Page 263.)*

When iron or steel is turned without any lubricant being used, it will present a very

rough surface. This effect is brought about by the metal seizing on to the cutting edge of the tool and presenting a rough edge to the work: consequently the turned surface will be rough also. Now, a lubricant such as soapsuds will prevent this seizing taking place; so the tool will always present the smooth cutting edge so necessary for producing a polished surface on the work.

E. F. K.

REPLY TO W. W.

Wetting Tramway Lines. *(Page 264.)*

The reason for the electrical tramways authorities keeping the rails well watered is because the rails are used as the negative or return conductors. This being so, it is necessary that they should present a clean surface to the wheels of the cars, through which the current leaves the motors. After a rain it is more necessary than ever to wash the rails because it would be a hard job to get them clean if the mud were allowed to dry on. E. F. K.

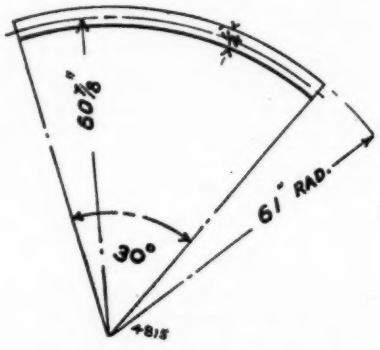
Almost every up-to-date electric-traction concern of any size have now their motor-driven water-tank for wetting the tram rails, and the prime reason for this is one of economy. It is a well-known fact among tramway engineers that when tram rails are clean and wet there is a clear saving of from 15 to 50 per cent. of power, and it would be interesting to see the published record of current consumed on a few large undertakings on days when rain has fallen and kept the track in a constant wet state, compared with the current consumed by the same service of cars on a dry day when dust is blowing about the track. Hence the water-tank is brought into use to put the rails as near as possible in the same state as on a rainy day, and, at any rate, if it is not possible to keep the rails constantly wet in dry and summer weather, the flushing of the rail with water once or twice per day does a powerful amount of good. The dirt which in dry weather sets hard in the groove of the rail causes the car wheels to revolve on two different radii, and offers a great amount of resistance to traction. Not only is resistance offered to traction by the proper bearing surface of the car wheels on the head of the rails, but the flanges of the wheel revolving on the hard caked grit in the rail groove increases the resistance, and more horse-power is exerted in starting and running the car. Especially is this so where bogie (eight-wheel cars) are much used, for, of course, the resistance increases proportionately to the number of wheels. After the water-tank has passed along the track, the next few cars, just by simply running over, spread the dirt to a certain extent on each side of the rail. When the rail gets dry there is a clean bearing surface, and the wheels make a good contact and no current is lost between the wheels and rails, which are the return for the current after it has passed through the motors. The Board of Trade allows only a small drop in potential in the return conductor also, and so the use of water on the rails helps to keep up the potential. Frequently, these tanks are fitted with appliances for cleaning the rails by ploughing the dirt out of the groove and brushing. With a power-station of limited capacity this wetting of the tram rails is almost indispensable.

TRAM RAILS.

REPLY TO A. B.

Length of Segment. *(Page 353.)*

The length should be worked on the mean radius of the segment, *i.e.* 60⅞ ins., as shown, and is equal to one-twelfth of the full circumference at this radius.



$$\text{Length} = \frac{60{\cdot}875 \times 3{\cdot}1416 \times 2 \times 30}{360} =$$

31·874, or practically 31⅞.

I do not know how "A. B." intends to bend these segments, but I rather think they will stretch a little in this process. The amount, however, can only be found by experiment, and would probably be but slight, as the segments are very deep compared with the thickness.

I have taken the 61-in. radius to be the external radius. S. W. A.

[The bending can be done by rolls or clamping to a radial bending block.—ED.]

Worm Gearing. *(Page 264.)*

Strictly speaking, it is not correct to say that power can be transmitted in one direction only by worm-wheel gearing. In cases where the pitch of the worm is large, the teeth of the worm-wheel smooth and in good condition, it is possible to reverse the direction of the power; that is to say, it is possible in such a case to drive the worm by the wheel. But, generally speaking, these conditions do not obtain. Whether the direction of transmission may be altered depends—(1) upon the pitch, and (2) upon the co-efficient of friction between the surface of a wheel-tooth and the worm. The second condition is, of course, a variable quantity. If the mechanism is dry or has been standing, friction is a large element of consideration; indeed, friction might be altered to "stiction." The effect of the pitch will be understood by a consideration of Figs. 1 and 2. Fig. 1 shows the general arrangement. An end view and a plan of the worm are given. In the plan only one wheel-tooth is shown, and that one in section (figured *abcd*). When the worm is turned in the direction of the arrow (Fig. 1, *B*) for half a revolution the tooth *abcd* moves to a second position *a'b'c'd'*. But the surface *ef* is *not* the same surface as the surface *g h*, for the worm turns round. Thus *ef* slides along *ad* in the direction *ad*, producing motion of *abcd* in the direction of the arrow *M*. As the worm is fixed for endwise motion, the process may be considered the equivalent of such a one as that shown in Fig. 2. A wedge by motion in the direction of the arrow *a* moves the block *B* in the direction of the arrow *b*. *B* is the wheel tooth, the wedge is the worm. A little consideration of the matter will easily explain that in any case of a screw we have simply an inclined plane wrapped round a cylinder. When the wheel is turned by the worm, we have a re-action due to the wheel in the inverse direction to *b*. The line of action of this re-action is evidently the line along which the force on the worm tooth must act to *tend* to turn the worm. Now, by a consideration of whether *B* would move if this force *R* was impressed, we can deduce

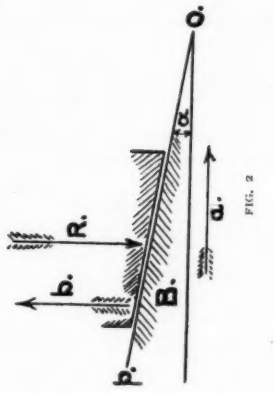


FIG. 2

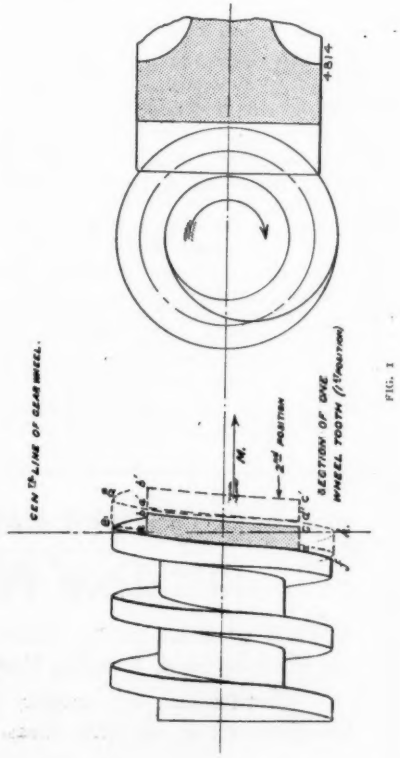


FIG. 1

the conditions of rotation of a worm by the application of a turning moment on its gearing wheel. If a = angle of wedge (or thread of worm) we have (revolving R along and perpendicular to $O P$)

$$\mu R \cos a = R \sin a$$

where μ = co-efficient of friction between surfaces. So that we have for the condition that there will be a movement

$$\tan a = \mu$$

and tan a, for a thread is evidently =

$$\frac{\text{pitch}}{\pi \times \text{diameter}} \text{ (at pitch line)} = \frac{p}{\pi a}, \text{ say.}$$

Therefore, for movement,

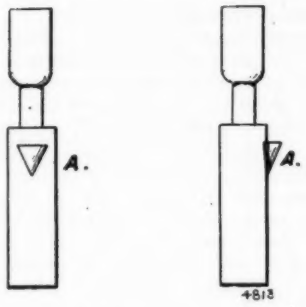
$$\frac{\pi a}{p} \text{ must be greater than } \mu.$$

Evidently, the smaller the pitch the less chance there is of any reversal of transmission of power. T. T.

REPLY TO ASPIRANT.

Drilling Glass. *(Page 353.)*

In reply to "Aspirant" one method of drilling a $\frac{1}{2}$-in. hole through $\frac{1}{4}$-in. glass is as follows:—Procure a piece of fairly hard $\frac{1}{2}$-in. copper tube, and fit a shank to one end to fit the drill spindle. The other end of the tube should be either turned or filed up true. See that the glass rests square and solid on the table. Feed the drill with emery and oil, and lift the spindle frequently to feed fresh emery in. If the drill is a vertical one the feed could be arranged as in the sketch. A is a triangular slot cut in the tube about $\frac{3}{8}$-in. wide and deep, and a piece of metal



in the shape of half a cone soldered over it. The oil and emery is fed in at A, and when the tube is lifted it feeds itself automatically. M. E. J. V. A.

QUERY.

Iron and Steel Manufacture.

In the manufacture of angles, tees, etc., which are commonly used in constructional iron and steel work is there any book published giving the gross weight of the bloom or pile before heating and rolling into finished bars and also stating the weight per lineal foot of the bars after rolling?

I understand there is such a book published for wrought-iron bars, but I am very desirous of obtaining a similar work for steel.

If there is no book published, I should be glad to learn what method is usually adopted for determining the size and weight of the bloom or pile before rolling into finished bars. A. E. D.

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Engineering Abstracts

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Amer. Engin. & Rlrd. Jnl.	American Engineer and Railroad Journal	NEW YORK.....	20 *cts.*
Amer. Machst.	American Machinist	NEW YORK	-/4
Amer. Machy.	American Machinery	NEW YORK	-/4
Ann. Ing. Gand	Annales de l'Association des Ingénieurs de Gand	BRUSSELS	*f.*2.50
Brit. Archt.	The British Architect	LONDON	-/4
Brit. Claywkr.	The British Clayworker	LONDON	-/6
Builder	The Builder	LONDON	-/4
Bldrs.' Jnl.	Builders' Journal and Architectural Record	LONDON	-/2
Bldng. News ...	Building News	LONDON	-/4
Canad. Imp. Trade	Canadian Implement Trade	.....	..
Canad Mfr. ...	Canadian Manufacturer	TORONTO.....	...
Coll. Gdn.	The Colliery Guardian	LONDON	-/5
Coll. Jnl.	The Colliery Journal and Mining Engineer	LONDON	-/6
Com. Intel......	Commercial Intelligence	LONDON	-/3
Compt. Rendu Soc. Ing. Civ.	Compte Rendu des Travaux de la Société des Ingenieurs Civils de France	PARIS	. 3.00
Contract Jnl.	The Contract Journal	LONDON	-/6
Echo des Mines et Metall.	L'Echo des Mines et de la Métallurgie	PARIS	p.a. *f.*45.00
Elec. Eng.	The Electrical Engineer	LONDON	s.c. -/3 p.a. 13/-
Elec. Rev.	Electrical Review ...	LONDON	-/4
Elec. Rev., N.Y.	The Electrical Review, N.Y.	NEW YORK.....	s.c. 10 *cts.* p.a. $5
Elec. Times ...	Electrical Times ...	LONDON	-/2
Elec. Wld.	Electrical World & Engineer	NEW YORK.....	s.c. 10 *cts.* p.a. $6
Electrician ...	The Electrician	LONDON	s.c. -/6 p.a. 26/-
Electricien ...	L'Electricien	PARIS	s.c. 50 *c.* p a. 25 *f.*
Electricity	Electricity...	NEW YORK.....	s.c. 10 *cts.* p.a. $4'50
Elec. Techr. ...	Der Electro-Techniker	VIENNA	60 *pf.*
Engineer	The Engineer..... ..	LONDON	s.c. -/6½ p.a. 29/-
Engineering ...	Engineering	LONDON	s.c. -/6½ p.a. 29/2
Eng. and Min. Jnl.	The Engineering & Mining Journal	NEW YORK.....	...
Eng. Gaz.	The Engineer's Gazette	LONDON	-/6
Eng. Rec.	The Engineering Record	NEW YORK.....	s.c. 12 *cts* p.a. $6
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Iron and Coal Trades Rev.	Iron and Coal Trades' Review	LONDON	-/6
Iron and Steel Trades Jnl.	Iron and Steel Trades' Journal	LONDON	-/3
Jnl. Gas Lighting	The Journal of Gas Lighting	LONDON	-/6
Jnl. Assoc. Eng. Soc.	Journal of the Association of Engineering Societies	PHILADELPHIA, U.S.A.	...
Jnl. Franklin Inst.	Journal of the Franklin Institute	PHILADELPHIA, U.S.A.	30 *cts.*
Jnl. I. E. E. ...	Journal of the Institution of Electrical Engineers	LONDON	...
Jnl. Iron & Steel Inst.	Journal of the Iron and Steel Institute	LONDON	...

Jnl. San. Inst.	Journal of the Sanitary Institute	London	...
Jnl. Soc. Arts	Journal of the Society of Arts	London	...
Jnl. Western Soc. Eng.	Journal of the Western Society of Engineers	Chicago, U.S.A.	...
Knowledge	Knowledge	London	-/6
Light Rly. & Tram. Jnl.	Light Railway and Tramway Journal	London	1/-
Machinery ...	Machinery	New York.....	25 *cts.*
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Marine Engg.	Marine Engineering	New York.....	25 *cts.*
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Mod. Machy.	Modern Machinery	Chicago	10 *cts.*
Nat. Ldry. Jnl.	National Laundry Journal	Chicago	15 *cts.*
Nature	Nature	London	-/6
Power	Power.....	New York.....	20 *cts.*
Proc. Am. Soc. C.E.	Proceedings of the American Society Civil Engineers	New York.....	...
Proc. Inst. C. E.	Proceedings of the Institution of Civil Engineers	London	...
Proc. I. Mech. E.	Proceedings of the Institution of Mechanical Engineers	London	...
Proc. Roy. Phil. Soc. Glasgow	Proceedings of the Royal Philosophical Society of Glasgow	Glasgow	...
Pub. Health Eng.	Public Health Engineer	London	-/3
Quarry	The Quarry.....	London	-/6
Rlrd Gaz.	The Railroad Gazette	New York.....	p.a. $6·08
Rly. Age	The Railway Age ...	Chicago	10 *cts.*
Rly. & Eng. Rev.	The Railway and Engineering Review	Chicago	10 *c.*
Rly. Mastr. Mech.	Railway Master Mechanic	New York ...	s.c. 10 *cts.* p.a. $1·00
Rev. Chim. Ind.	La Revue de Chimie Industrielle	Paris	p.a. *f.*12.00
Sc. Amer.	Scientific American	New York.....	8 *cts.*
Stahl u. Eisen	Stahl und Eisen	Düsseldorf ...	p.a. 24 *mks.*
Steamship	The Steamship	Leith	-/6
Stev. Inst. Indic.	Stevens' Institute Indicator	Hoboken, N.J.	50 *cts.*
Street Rly. Jnl.	Street Railway Journal	New York.....	s.c. 50 *cts.* p.a. $6.00
Surveyor	Surveyor	London	-/3
Tram. & Rly. Wld.	The Tramway and Railway World	London	1/-
Trans. Am. I. E.E.	Transactions of the American Institute of Electrical Engineers	New York.....	...
Trans. Am. Soc. Mech. E.	Transactions of the American Society of Mechanical Engineers	New York.....	...
Trans. Am. Soc. Nav. E.	Transactions of the American Society of Naval Engineers	New York.....	...
Trans. Inst. Eng. & Shi, bldrs.	Transactions of the Institution of Engineers and Shipbuilders in Scotland	Glasgow	...
Westn. Electn.	Western Electrician	Chicago	10 *cts.*
Zeitschr. Vereines Oster. Ing. und Arch.	Zeitschrift des Oestereichischen Ingenieur und Architekten-Vereins	Vienna	60 *hr.*
Zeitsch. Elektrotechnik.	Zeitschrift für Elektrotechnik	Vienna	p.a. 20 *mks*
Zeitsch. Elektrochemie	Zeitschrift für Elektrochemie	Halle à S., Germany	4 *mks.* per qr.

Any of the above-mentioned publications can be obtained on application to Messrs. Williams & Norgate, Henrietta Street, Covent Garden, London, W.C.

MATERIALS AND MEASUREMENTS.

Indiarubber.

SECRECY has been like a pall for years over the science of indiarubber. Every other material which has fallen into the hands of electrical technicians has been studied, and the information obtained has been placed on record. With indiarubber the case has been so different, that its prospects as an insulator are seriously impaired by a feeling of distrust. Carl O. Weber is doing good work by publishing his book on the Chemistry of Indiarubber, the literature of which is extremely scanty and generally untrustworthy. Respecting the chemical character of the resins separated from rubber nothing at all is known, yet their technical effect is important owing to the immense quantity of sulphur which they require for their own use, and of which they rob the rubber during the vulcanisation process. Indiarubber vulcanised with an insufficient amount of sulphur is known to be highly perishable, and a truly scientific treatment, by which impurities are measured or allowed for if not removed, would enormously enhance the value even of cheaper brands. Besides the resins, there are sugars, albuminous bodies, vegetable fragments, sand, and other accidental impurities, all easily removable. To electricians, it is of paramount importance to remember that there is an impurity in technically pure rubber, generally known as "ash," and being the mineral residue after incineration, it may represent mineral matter in an extremely fine state of subdivision, but a large part of it is undoubtedly in the form of organic salts. If we accept the electrolytic theory of dissociation, even absolute insulation would not protect us against decomposition of a dielectric by the electrostatic attraction of the ions of an electrolyte, if such an electrolyte be on either side of the supposed absolute insulator. The existence, therefore, of unremovable organic salts in indiarubber may have a more important bearing on its permanency under continued electrical stress than is usually supposed.—**Mervyn O'Gorman,** *Elec. Times, April 2, 1903*, pp. 567–8.

The Balancing of Marine Engines.

IN an unbalanced engine two distinct sets of forces give trouble—(1) those set up by unbalanced rotating parts, and (2) those caused by unbalanced reciprocating parts. The practical effects of the former are undue wear and tear and heating of bearings, or if the bearing surface is ample the engine seatings may be sprung, thus permitting the whole engine to move with the eccentrically moving shaft; or if the seatings are rigid the whole hull of the ship may move with the engine and thus be made to vibrate. The forces set up by vertical reciprocating parts tend to move the whole engine and ship up and down, or, when acting away from the vertical centre line, to tilt the engine endwise. In either case deterioration of the ship's structure and discomfort to passengers and crew are likely to follow. The unbalanced parts of the crank-arms, the crank-pin, and that part of the connecting-rod weight located at and revolving with the crank-pin centre, can be truly balanced by balance weights. But to properly balance the piston, piston-rod, crosshead, and the remaining portion of connecting-rod, two cranks or two eccentrics placed symmetrically on either side of the engine-crank must be employed, and these must be coupled to suitable balancing-weights and must cause them to reciprocate in a direction opposite to that of the reciprocating parts themselves. The commonly used arrangement, in which the rotating balance-weights are made heavy enough to balance not only the rotating weights, but also a part of the reciprocating weights, does not in any way balance the forces set up by the reciprocating parts. The theoretically correct method of balancing reciprocating parts by the addition of "bob" weights involves so much cost, weight, and complication that what are known as "collective" methods have been devised. The object of such methods is, not to balance the moving parts in connection with each cylinder independently, but so to space the centres of the various cylinders, so to arrange the various crank-angles, and so to proportion the weights of moving parts, as to cause the whole of the disturbing forces to cancel out. Collective balancing can be carried out more or less completely in some engines, but in others it is impossible, and then recourse must be had to independent balancing or partial balancing by counter-weight. The author then discusses in detail the balancing of vertical engines with one, two, three, and four cranks, and gives rules for the construction of diagrams displaying the manner in which unbalanced forces in any engine vary during a complete revolution, for determining the forces arising from the action of unbalanced parts, and for the purpose of ascertaining if the various parts of a proposed engine will be in balance. In conclusion he shows that, before carrying out any scheme of balancing, care should be taken to ascertain its effect upon the curves of turning moment, and that the questions of interchangeability of crankshafts and of ease in starting should be borne in mind when

setting crank angles and distances between cylinder centres.—**H. M. Roundthwaite,** *Proc. Inst. Marine Eng., Session 1902-3 Vol. XIV.*, pp. 3-41.

CONSTRUCTIONAL.

Properties of Brick under Different Physical Conditions.

THIS paper is based upon tests conducted in the civil engineering laboratories at Cornell University in 1901. The methods of procedure, the results of the tests, and the outline of the conclusions are given. All the bricks used in the investigation were common building brick, measuring about 8 ins. by 4 ins. by 2 ins. The tests conducted were as follows :—(1) Compressive tests of whole brick, on end, edge, and flat, and of brick cubes ; (2) tension tests ; (3) bending tests ; (4) shearing and torsion tests. The conditions were —(1) Natural brick ; (2) brick filled with water ; (3) reheated brick. In testing brick under the three conditions the author had in mind brick used in dry places, in wet places, and after having passed through a great fire. The following table collects the average results contained in fourteen tables given in the paper :—

Condition.	Ultimate Loads and Maximum Fibre Stresses in lbs. per sq. in.						
	Compression Net Loads.			Tension Net Loads.	Bending Fibre Stresses.	Shearing Net Loads.	Torsion Fibre Stresses.
	End.	Edge.	Flat.				
Natural	2,628	2,832	3,995	201	863	445	609
Filled with water	2,320	2,717	4,562	209	783	384	518
Reheated	2,871	3,326	4,939	225	832	446	487

By comparing the averages it will be seen that in every case brick on the flat are the strongest, those on edge next to the strongest, those on end next to the weakest, while the cubes are the weakest. It will also be seen that in all cases reheated bricks are the strongest, while bricks filled with water are the weakest in the end and edge tests, and that natural bricks are weakest in the flat tests. The most important tests are tension and compression, and of these tension is the more important, as it is the weaker stress. Bending is a more important test than shear, as strain along this line is more likely to occur than in shear. — **Sherman M. Turrill,** *Proc. Am. Soc. C.E., March, 1903, Vol. XXIX., No. 3*, pp. 226-55.

Types and Details of Bridge Construction.

IN this chapter, and those which are to follow, it is the writer's purpose to present descriptions and illustrations of types of bridge construction, and to give the essential data of notable and peculiar structures. Most of the structures and details have been previously described in technical journals, and these articles will form a classified collation of examples selected to show the development of design, and to record it for convenient reference, and for the comparison of works actually built.—**Frank W. Skinner,** *Eng. Rec., April 11, 1903, Vol. XLVII., No. 15*, pp. 378-80.

Theory and Calculation of the Two-Hinged Arch.

THIS article presents a method by which the two-hinged arch can be constructed so that the stresses may be calculated with some degree of certainty of their being those of the finished structure. The lines of investigation follow those of Mohr, Winckler, and Mueller-Breslau. Also wind stresses have received more than usual attention.—**Alex. Rice McKim,** *Eng. Rec, April 11, 1903, Vol. XLVII., No. 15*, pp. 380-82.

Deflections of Beams with Variable Moments of Inertia.

THE determination of the deflections for solid-webbed girders has hitherto been chiefly confined to girders with a constant moment of inertia, and such determinations have usually been made by means of the equation of the elastic curve. The purpose of this paper is to give a more general method for determining the deflections of solid-webbed girders, and to illustrate its application to the forms of girders most frequently met with in practical bridge construction. Application of the general formula, recommended by the author, is also made to the plate-girder drawbridge, with the object of giving a simple method of making a

better design for the girders and end-lifting machinery for such bridges.—**C. W. Hudson,** *Proc. Am. Soc. C.E., May 1903, Vol. XXXIX., No. 3,* pp. 264-80.

Notes on Cement Masonry.

MUCH of the matter in this paper relates to tests of Portland cement, and on this subject the author has nothing to say that is not already known. His experiences as a user of cement show that holder tank work and engine foundations can be successfully put in during freezing weather if a brick is used that will quickly absorb the excess of water from the mortar. He finds it a mistake to use hot water in making the cement mortar, or to make the sand and brick hot. When there is not enough sensible moisture to produce expansion by freezing there can be no damage. Sometimes, in setting a new engine or machine in an old foundation, the author has put in foundation bolts by drilling holes but little larger than the bolts, hanging the bolts in the hole and then pouring in a neat Portland cement grout filling. He has set engines of 30 to 50 h.p. with all the bolts held in this way, and started up under full load in a week. The advantages of Portland cement lime mortar are cheapness, rapid hardening, marked hydraulic properties, great strength on exposure to air and remarkable resistance to weather. The following proportions are recommended :—

CEMENT.	SAND.	LIME PASTE.
1 part	5 parts	0·5 parts
1 ,,	6·7 ,,	1·0 ,,
1 ,,	8 ,,	1·5 ,,
1 ,,	10 ,,	2·0 ,,

Hydraulic lime may be used in place of ordinary slaked lime. In preparing for a foundation of cement masonry it is essential that the excavation be thoroughly drained, so that the concrete or footing courses of stone may go in dry, and no water rise on the masonry until the cement mortar has thoroughly set. Precautions must also be taken against flooding of the excavations by surface water in case of rain. Concrete can be put in in freezing weather if covered with earth or manure, and it must not be allowed to freeze until the excess of water is gone. Concrete cannot be rammed against soft ground or on sandy ground. In the first case it is better to throw in broken stone and tamp down, and in the second the ground should be planked over to tamp against. In setting large dimension stones, such as engine beds, pier copings, column base stones and the like, the author allows for a one-inch joint to bed the stone. He then sets the stone on hardwood wedges, clamps it in place by the foundation bolts, and then tamps Portland cement mortar into the joint under the stone with a hardwood tamper or steel bar. Engines, pillow blocks, floor stands and heavy machinery set on a stone or brick foundation can be bedded down in the same way.—**I. N. Knapp,** *Stevens Inst. Indicator. Vol. XX, No. 1, Jan. 1903,* pp. 14-16.

TRACTION.

Railroad-Car Braking.

THIS paper contains a very complete investigation of the subject of railroad-car braking, and gives a most valuable summary of the knowledge and data already obtained and an instructive statement of problems still unsolved. After sketching the practical development of brakes in railroad service, the author analyses the results of investigation of brake-shoe friction, dealing at some length with the Westinghouse-Galton tests on the London, Brighton and South-Coast Railway in 1878, and defining the requirements and limitations of brake-efficiency in practice. The maximum retardation which may be utilised in stopping railroad-vehicles by brakes is that which is realised by so applying brake-shoes to the wheels that the resulting brake-shoe friction shall be uniform and just insufficient to overcome the constant static rail-friction. If the latter be overcome by the brake-shoe friction, the wheels slide on the rails and the co-efficient of rail friction immediately declines. Ideal efficiency would be obtained in the time of necessity if the brake-shoes could be applied to the wheels so that a retarding rail friction equal to one-fourth the weight of the train is instantly realised and continuously maintained throughout the stop, but there are many obstacles to the realisation of such efficiency—notably the complicated variation of the co-efficient of brake-shoe friction. One feature of the question, usually overlooked but considered carefully by the author, is the distribution of pressure upon the rails. If the weight of the car is not equally distributed on the wheels, the brake-shoe pressure must be made to differ correspondingly ; and as brake retardation itself causes redistribution of the weight, there inevitably results a serious loss of braking efficiency unless means be taken to vary the brake-shoe pressure to correspond with the changed wheel-pressures. The author draws attention to the tilting effect of the momentum of the car body and the resulting difference in the pressure applied to the track through the front and rear wheels of the truck, and he

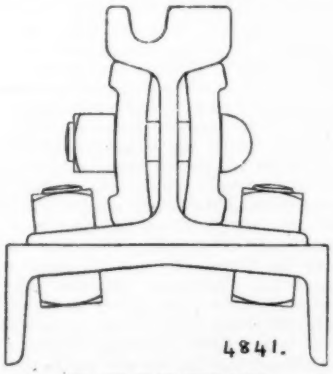
shows how to remedy this difficulty by hanging the brake-shoes at a particular angle, and between the wheels instead of outside. The paper concludes with a brief discussion of the peculiar characteristics of the magnetic brake, notably its property of actually increasing the rail-pressure of the wheels while leaving the friction of the wheel-brake unimpaired. —**R. A. Parke,** *Trans. Amer. Inst. E.E., Jan. 1903*, pp. 29–69.—*H.*

Some Theories upon Railroad Location.

RAILWAY location is an extremely important subject at the present time, partly because Canada is entering an era of railroad construction unequalled in magnitude by any that she has passed through since the completion of the Canadian-Pacific Railway main line, and partly because the critical study of railroad transportation has established principles which call for the almost complete reconstruction of the more important of the older lines. This paper contains a careful study of the subject, and is illustrated with several maps and two diagrams.—**J. G. G. Kerry,** *Trans. Can. Soc. C.E., March, 1903.*

Telodynamical Traction.

THE system of traction for railway trains by means of an endless rope has been known for a long time, this being the most simple and most direct method of transmission of motion from a stationary motor to the running train. This telodynamical transmission, however, in the form generally in use—*i.e.* with one motor working at the end of the line, or in any other point of the track—is applicable only to very limited distances. The author shows, in fact, that in a telodynamical transmission 30 kilometres in length the dynamic power of an endless rope will be completely exhausted by the resistance the rope has to overcome. Taking into account the influence of gravity as well as of the *vis viva*, this limit is found to be still further reduced. The author has, therefore, tried to meet this drawback by working the endless rope, instead of by one sole motor, by a whole series of motors conveniently distributed along the line, transmitting directly, section per section, the force necessary to overcome the passive resistances thus fractionated. As these motors have to run at a velocity strictly the same, it is convenient to choose electro-motors ; but gas-motors, in connection with a proper signalising system, may as well be used. The ideal system would be to impart a movement of its own to every pulley the rope is passing over ; but it is practically sufficient to allow the resistances to accumulate over one or two kilometres, provided they do not assume any disturbing intensity. The losses of power due to the transmission are for a mean length of 20 kilometres of about 50 per cent. ; but it must be remembered that this power, as produced by hydro-electric or gas motors, is less than half as expensive as the power developed by locomotives. Moreover, this efficiency does not vary with the velocity. —**A. Ferretti,** *L'Elettricità, April 26th, 1903*, pp. 264, 265.—*A. G.*



THE LIFE OF TRAMWAY RAILS.

The Life of Tramway Rails.

IT is important that the chemical constitution of rails should be very carefully specified, and the actual constituents ascertained before any rails are accepted. Samples should also be subjected to physical tests. Of the impurities most frequently found in rails sulphur and phosphorus are the most common, and should be guarded against as being productive of rapid disintegration. The hammering and rolling effect of traffic should rather improve than deteriorate the quality of the metal, but wearing of the surface must still continue. In the case of rails laid in cast-iron chairs on sleepers, galvanic action must take place between the steel rail and the chair, and excess of manganese or carbon will facilitate such action, and shorten the life of the rail. Galvanic action does not take place to the same extent in tramway rails ; and the electrical effects, or defects caused electrically, may be eliminated in considering the life of rails. The best chemical composition of rail steel is stated as follows :—

Carbon ...	...	·45 to ·50	per cent.
Silicon ...	...	·06 ,, ·08	,,
Phosphorus	...	·06 ,, ·08	,,
Sulphur ...	...	·05 ,, ·06	,,
Manganese	...	·80 ,, 1·00	,,

From the mechanical standpoint experience shows that wear at the joint is such that the life of the joint is the measure of the life of the rail. In many recent street tramways the fish-plates are supplemented by sole plates, stiffening the joint to some extent; but investigation shows that the strength of the material is not fully utilised. The "anchor" joint has two advantages, inasmuch as the rail cannot "creep" or hammer the concrete; but still the material is not used to the best advantage. The figure reproduced illustrates an arrangement considered by the writer to be an improvement, consisting of a specially rolled channel, in which the upper inside surface is parallel to the upper surface of the rail flange. This makes it possible to use ordinary square-headed bolts and nuts, avoiding the necessity for rivets. The metal in the channel is so disposed as to give the greatest rigidity with the smallest amount of metal; it has all the advantages of the anchor, so far as creeping is concerned, and is anchored to the concrete by putting a bolt transversely through it.—**R. P. Wilson,** *Tram. & Rly. Wld., April 9, 1903, Vol. XIII*, pp. 358, 359.

Electrification of Railways.

THIS is a paper read before the *Verein für Eisenbahnkunde.* Considerable improvements have been made of late years in the electric operation of railways, the methods of which ought to be essentially different from those used in connection with tramways for intra-urban traffic. Besides some important plants on the Italian, French and Swiss railways, there has to be named the experimental electric operation of the *Wannseebahn.* The object of the latter had been to establish by extensive measurements the main principles for the management of such plants, and to afford a proof of the reliability and cost as compared with the steam system. The experience gained will afford a means of establishing for any special case the proper method of construction. As regards the management, the electric operation of trains has been found to be entirely reliable and safe from disturbances. An essential advantage is the opportunity of forming single-train units with independent driving-power, a system highly qualified for meeting the varying emergencies that might arise in the operation of suburban railways, whereas a similar adaptability is quite impossible in the case of the steam system. As regards the cost of operation, a cost of 6 pf. (¾d.) per kilowatt-hour seems not to be superior to that of the ordinary system. By properly utilising the enormous adaptability of the electric system, much inferior costs are likely to be realised. Among the additional advantages there is the absence of smoke and soot, as well as the fact that no noise is produced on starting. As to the starting acceleration, a point of great importance in connection with suburban railways, great advantages are equally obtained by the electric system. On account of the adhering weight being distributed over a greater number of axles, the superstructure will have to meet much lower demands. In order to complete the experience gained with the *Wannseebahn* tests, it is contemplated to run the suburban railway, Berlin—Gross-Lichterfelde-Ost—by electricity, the execution of this plant being given to the care of the Union E. G. Continuous current will be supplied by the Schöneberg South-West Electricity Works by means of rails parallel to the track, in a manner similar to the system used in connection with the *Wannseebahn.* The trains will include three four-axle motor carriages, the terminal cars containing four third-class places, a guard's compartment and a luggage room; the intermediate car, 58 second-class places; and a fire-place room for the steam heating of the train. The carriages are each provided with two motors, capable of being controlled from the guard's place at the head of the train, and electric light will be employed throughout. The trains are, for a beginning, to be run at the same intervals as with the ordinary system, the same speed also being maintained so as to be able to make reliable comparisons between the two methods.—**Bork,** *Stahl und Eisen, April 1, 1903*, p. 478.—A.G.

American Locomotive Practice.

IN the first part of this paper the author points out that locomotive builders in America have so reduced cost that the railway companies cannot compete with them, whereas at home the companies meet requirements at their own works, and only place out contracts when demands exceed the capacity of their shops. American contract shops have no large demand from colonies as have British locomotive firms, of whose total work about 50 per cent. is for abroad. American builders, having the work in their own hands, can practically build engines to suit themselves, whereas British railway companies supply the contractors with full drawings down to the minutest detail. The American system is said to reduce first cost while rendering repairs expensive, because American locomotives generally are not standardised, each firm having its own standards for details. The work on contract-built American locomotives does not approach the standard deemed

necessary at home. The second part of the paper is entirely occupied with details of modern practice in America, the main difference between American and British locomotives being said to rest in the frames, for many of the others arise from this one. In the third section of the paper examples are given of the types of engines called into existence in recent years to cope with the continued demand for increased power. Double heading is not approved, and many lines now have engines capable of dealing with their heaviest trains. It is stated that, comparing the largest engines of the present day, under favourable conditions, with the lighter engines of the past, a decided economy is shown. On the other hand, favourable conditions, such as maximum train loads, are not always realised, and the large engines do not then maintain their advantage.—**P. J. Cowan,** *Proc. Inst. C.E., Session 1902–3. Private Press, No. 13.*

Electric Traction without Rails.

THIS is an illustrated description of the *Système Marcher*, for the traction of vehicles along ordinary roads by means of power derived from overhead conductors, arranged in a manner similar to that adopted in the case of tramways. Some half-dozen installations of this kind are said to be already at work on the Continent, and a dozen others to be in course of construction.—**A. Bancelin,** *L'Électricien, April 4th, 1903, Vol. XXV., Ser. 2, No. 640,* pp. 215–17.

POWER AND TRANSMISSION.

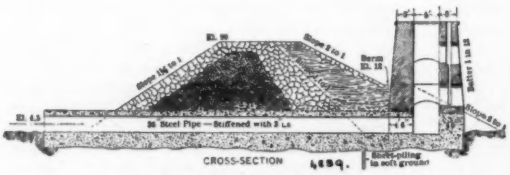
Power Transmission by Gas.

IN order to obtain all the advantages of the transmission of power by gas, the producer station should be near the field where the coal is obtained, so as to reduce the cost of transport, and the size of the plant should be from 20,000 to 30,000 h.p. As in most cases there will not exist in the immediate neighbourhood any large demand for power, or gas for heating, it will be necessary either to transform the gas into electricity, or else to transmit the gas itself into pipes. Of the total gas produced 60 per cent. will probably be used for heating purposes and the remainder for power. An advantage attending the transmission of gas is the better load-factor obtainable. With the moderate velocity of 30 ft. per second a transmission length of nearly 80 miles could be reached, with a pressure of 44 lbs. per sq. in. and an efficiency of nearly 90 per cent. A main 4 ft. diameter would under these conditions transmit nearly 57,000 h.p. The gas should be led to substations from which mains would distribute it to customers at low pressure. At these stations there would be placed large gas engines for the production of current at 5,000 to 15,000 volts, according to local requirements. Current for lighting and traction would be furnished from converters at suitable points, and manufacturers could be supplied either with polyphase current at reduced tension, or with continuous current. The greatest objection to the transmission of gas under pressure appears to be a doubt whether a sufficiently gas-tight joint could be obtained; but modern engineering should be quite capable of making a joint in which the leak should not exceed one-tenth of 1 per cent. per mile. An important matter arising out of the general use of gaseous fuel is that a complete solution of the smoke problem would be furnished. The use of such fuel would save from one-third to one-half of the total coal and add to the comfort and happiness of every individual.—**F. W. Burstall,** *B'hm. Sec. I.E.E.*, Meeting March 25th, 1903.

WATER.

A Small Rock-fill Dam.

THE dam described impounds water for an estate in New Jersey, and it was decided that a rock-fill structure, backed with earth on the water side, was the most expedient. Further, it was estimated that the cost of such a dam would be less than one-third the cost of a masonry dam of equal size. In commencing the dam proper the brook was allowed to follow its natural course until the rock-fill began to dam it up, when the water was passed through pipes. The work could thus be carried on from beginning to end in a dry state without the use of coffer dams or other falsework. The rock-fill was of stone, simply dumped on the work. Care was taken to build up the wall in horizontal layers and to use enough small stones to fill the voids as far as possible. All stones were carefully cleaned before being put into the wall, and all smooth stones were rejected. The best shaped stones were reserved for



A SMALL ROCK-FILL DAM.

the two faces, which were packed by hand, about 5 ft. thick on the downstream face, and on the upstream face from 5 ft. at the crest to 10 ft. at the toe. This packing was intended to help make the dam watertight, and to permit overflow without material injury. The earth-fill consisted almost entirely of clay, and was carried up in horizontal layers, each about 6 ins. thick, and each layer was well watered and rolled. At the east end of the crest a rubble abutment was built, and a light steel bridge extended to the top of the gate house. The main dimensions of the dam are:—length on crest 235 ft., height at centre 20 ft., total width of crest 15 ft. The contract price was $8,700. —**H. de B. Parsons,** *Proc. Am. Soc. C.E., March 1903, Vol. XXIX., No. 3,* pp. 256–63.

Recent Irrigation in the Punjab.

THE Chenab Canal was developed from a small inundation scheme to irrigate part of the Rechna Doab into a large perennial canal, which will eventually command the entire tract between the Ravi and Chenab rivers. This is one of the latest irrigation schemes in India, which will open an immense tract of waste crown land to cultivation. The author explains the manner in which the waste land has been blocked out and levelled so as to obtain an accurate contour map, and describes various works carried out by the canal engineer for transformation of the region into a settled community. Among other matters discussed in the paper are: the principles applied in aligning and grading all the channels of this vast system and of the calculation of their capacities; the system of water distribution both in the Government channels and the village watercourses; the duty of the water and the manner in which it was calculated both for the main and distributing canals; and the precautions necessary for guarding against over-irrigation and consequent damage to the soil. —**S. Preston,** *Proc. Inst. C.E., Session 1902-3, No. 11.* Paper read March 10, 1903.

BATTERIES, ACCUMULATORS, AND ELECTRO-CHEMISTRY.

Improvements in Edison Storage Battery.

TWO patents have been granted to Mr. Edison upon an improved electrode for his storage battery, wherein an alkaline electrode is used with insoluble active materials. One patent is intended to obviate the bulging of the electrode by the swelling of the active material, when immersed in the electrolyte and subjected to a charging current. To overcome this difficulty, the receptacle is made with concave faces when the electrode is first assembled. The swelling of the active material then does not bulge the electrode objectionably. The second patent covers a method of securing better electrical contact between the particles of active material of the iron element in the nickel-iron storage battery. In this patent a combination of mercury, and one or more other readily reducible metals, such as copper, is claimed specifically.—*Elec. Rev. (N. Y.), April 25, 1903, Vol. XLII., No. 17,* p. 509.

Corrosion by Electrolysis.

A FEW years ago the impression prevailed to some extent that underground mains made of Scotch iron were immune from electrolysis, owing to a thin silicious compound, of the nature of glass, found on the surface of the pipes. Prof. Sheldon has stated that this coating is extremely thin and contains perforations. Such a condition is a good reason for the earlier rupture of a main, since if the corrosion were more evenly distributed over the surface, as at the perforations, or spots, where there is no coating, action will naturally localise, and the iron be penetrated more rapidly. The lengths of pipes, while being handled, are often rolled over other lengths or hard substances, and this may cause a removal of the coating, and the consequent localisation of electrolytic action, which follows the line of the bare iron. The absence of frequent failures of mains from this cause should not be taken as evidence that electrolysis does not exist; its progress may be slow, and will not be discovered unless looked for. A main may be nearly ruined by electrolytic action, but owing to the pressure of surrounding soil, will hold together, and not reveal its state through final bursting for a long time. The only complete solution for electrolytic corrosion of underground metals by railway currents, is what is commonly known as the double trolley.—**A. A. Knudson,** *Proc. Am. Electro-Chem. Soc.* Meeting held April, 1903.

Formation of Insoluble Deposits in Electrolysis with Soluble Anodes.

THE author deals with the Luckow process of preparing insoluble or hardly soluble deposits by electrolysis. In this process an electrolyte including, in addition to the salt with the desired acid radical, another indifferent salt is used in connection with anodes of the desired metal, the acid radical of which will form with the metal of the anode a readily soluble compound. A case recently investigated by Le Blanc and Bindschedler was the preparation of chrome yellow with lead electrodes immersed in a solution of potassium chromate and potassium chlorate, when lead chromate would easily be formed,

without any deposit settling on the anode, as long as the concentration of the chromate ions was small as compared with that of the chlorate ions, whereas for increasing concentrations of the chromate ions, disturbing secondary phenomena would gradually be noted, the deposit adhering more and more closely to the anode, lead peroxide being formed and the current efficiency being lowered. Now, the following explanation of this striking fact is found to be true: Lead ions will be evolved at the anode, uniting with the chromate ions in the immediate neighbourhood of the latter. In the case of high concentrations of the chromate ions, those consumed may readily be supplied by migration, the chromate deposit thus being capable of adhering to the anode, whereas in the case of the concentration of the chromate ions being low, those present will rapidly be consumed, without any adequate supply taking place. The thin layer of chromate and peroxide will therefore rapidly be destroyed, lead ions accumulating instead of chromate ions. The author next tests some devices for unipolar conduction in connection with the above process, a noticeable condenser effect being observed only in the case of valve cells with aluminium anodes. Pure ceruse, for the production of which the process was originally devised, is found to be obtained only within a limited range of concentration of the carbonic acid contained in the electrolyte.—**A. Isenburg,** *Zeitschrift für Elektrochemie, April 9, 1903*, pp. 275–83.—*A. G.*

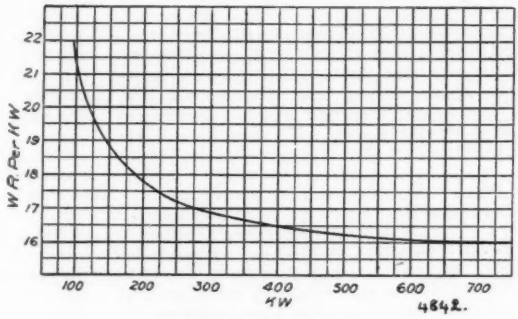
Electrolytical Method for Obtaining Metal Powders.

WHEN electrolising a solution of a metal compound in connection with a mercury cathode the corresponding amalgam will be obtained, this method being applicable even to such metals as are commonly regarded as unamalgamisable, *e.g.* platinum and iron. By a suitable arrangement the author has succeeded in preparing even aluminium, sodium, potassium, etc., amalgams which are decomposed by water. These amalgams are spongy substances, filled with mercury particles, their specific weight being intermediary between those of mercury and the corresponding metal. If the cathode vessel has a permeable bottom the amalgam will get on to the surface, where it may be easily taken off; if the bath contains several metals it will depend upon the current density which is deposited. The amalgam desired may therefore be electrolytically purified, not only from unamalgamisable bodies, but from any other metals. On strongly compressing in linen bags the amalgam thus cheaply obtained nearly pure mercury is drawn off, the amalgam being partially decomposed; a substance easily pulverised will remain, made up of amalgam and metal powder. If this mass be subjected to distillation at a temperature inferior to the melting-point of the amalgam the mercury will separate from the metal (especially in the case of iron and related metals), the latter remaining in a spongious, friable condition, so as to be pounded to an extremely fine powder in a mortar. When choosing convenient atmospheres for this distillation, various metal compounds may be obtained. Distilling iron amalgam in a reducent medium will, for instance, give pyrophoric iron, which by convenient treatment may be converted into common iron. Oxidising mediums will yield some hitherto unknown iron oxides and protoxides. An investigation of Edison's accumulator had suggested this process, which was originally intended for obtaining ferro-oxide in an expedient way.—**A. Zamboni,** *Elettricità, No. 4, 1903.—A. G.*

The Ruhmkorff Coil and recent Rapid Vibrators.

AFTER referring to some characteristics of the well-known Ruhmkorff coil, the author says that the advantages of a rapid separation of vibrator contacts being clearly established, inventors have lately turned their attention in this direction. Recent interrupters are, in fact, so rapid in action that their name has been shortened to *rupteurs*. Some of these devices are described in this article. The "Rupteur Atonique," of M. Carpentier, derives its name from the slender vibrator tongue, which, being of soft iron, has little elasticity, and takes a movement that is totally non-periodic. The break is very quick, and the spark is always produced at a uniform interval after the opening of the primary. The "Chauvin et Guerre Interrupteur" is chiefly intended for electric ignition coils of internal combustion engines. One fault of many vibrators is that they do not give a sufficient number of sparks per second. Spirit motors are limited to about 1,200 revolutions per minute owing to this cause. MM. Chauvin and Guerre have now introduced an interrupter giving 436 breaks per second, instead of 80 to 85, as hitherto; therefore the speed of small spirit motors could be increased, if necessary, to 5,000 revolutions per minute. The vibrating tongue in their device is of magnetised steel, and its mass is reduced to a minimum. The characteristic of their apparatus is the sudden arrest in the movement of one of two pieces of the interrupter, the two parts simultaneously separating almost at the same instant. One other example, the "Rupteur Many," is adaptable to coils of any descrip-

tion, and this appliance is characterised by the employment of a balancer accompanying the vibrator tongue, the balancer being arrested by striking one end against a part of the frame. Referring, in conclusion, to the advantages of rapid interrupters, the writer remarks that when the parts of a vibrator are in contact the current established rapidly acquires its full normal value. If the break does not immediately follow, the current that continues is pure loss, heating the contacts and wasting the energy of the accumulators. In automobiles economy of such energy is very necessary, and the great advantage of rapid interruption may be further realised by considering the increase of power that might be obtained if "mis-fires" were eliminated from the action of ignition apparatus. — **M. Aliamet,** *L'Électricien, April 4, 1903, Vol. XXV., Ser. 2, No. 640,* pp. 209–12.



THE CURTIS STEAM TURBINE.

PRIME MOVERS.

The Curtis Steam Turbine.

SINCE 1895 the inventions of Mr. Curtis, of New York, have been the subject of investigation at Schenectady, the object being to establish data and laws which would form the basis for the correct design of the Curtis turbine for practical use. About two years ago the results of these experiments gave data showing great commercial possibilities, and contracts for these machines now aggregate 230,000 h.p. in turbine-driven electric generating plant, the largest size so far built being of 7,500 h.p. Very little information concerning the great industry thus brought into existence has reached the public, and the present paper is the first printed matter which has appeared on the subject. The Curtis turbine retains some of the features of its predecessors, but introduces new ideas which make possible a much lower speed, less weight, fewer and simpler parts, higher economy, less cost, and other important advantages. Its functions may be thus briefly described. Velocity is imparted to the steam in an expanding nozzle, converting nearly all the expanding force. Steam passes from the nozzle through two or more lines of vanes on the moving element, placed alternately with reversed vanes on the stationary element. The velocity acquired in the nozzle is fractionally abstracted and largely given up to the moving element. Steam is first thrown against one set of vanes, and then rebounds from moving to stationary vanes until it is brought nearly to rest. By these means a high steam velocity imparts motion to a comparatively slow-moving element. The process of expansion in nozzle and abstraction of velocity by impact is generally repeated two or more times, the devices for each repetition being called a stage. There may be several stages and several lines of vanes in each stage, the numbers being governed by the degree of expansion, the desired or practical peripheral velocity, and by various conditions of expediency. Governing is effected by the successive closing of nozzles, and the consequent narrowing of the active steam belt. The most important advantage claimed for this machine is the high steam economy afforded under average conditions. Several curves are given by the author, one of which we reproduce. It is stated that a 5,000-k.w. unit will shortly be put into operation in Chicago. This machine is expected to give considerably better steam economies than are shown by the 600-k.w. machine from which the above-mentioned curves were obtained.—**W. L. R. Emmet,** *Street Rly. Jnl., April 11, 1903, Vol. XXI., No. 15,* pp. 564–68.

Stresses on Frames of Vertical Inverted Steam Engines.

THIS communication is the translation of an article contributed by G. Schwarz to the *Zeitschrift des Vereins Deutscher Ingenieure.* It is a mathematical investigation, leading up to equations indicating all single moments, and with these moments can be found all bending stresses, which, in connection with the tensile and compressive stresses of the piston force, form the total

stress on the frames. It is also important to find the stress on the connection bolts at the cylinder and bed-plate ends of the frames respectively. In addition to the stress from the piston force, the bending moments produce stress on the bolts, the latter stress being sometimes greater than the former.—**John H. F. Meyer,** *Jnl. Am. Soc. Nav. Archts, Vol. XV., No. 1,* pp. 19–38.

Greasy Condensation Water as Boiler Feed.

ONLY when overheating takes place is attention generally given to this question. The usual explanation is that grease is a bad conductor of heat, but even a film of considerable thickness could not offer such resistance to the passage of heat as to cause overheating. In the author's opinion, the explanation is not that grease is a bad conductor of heat, nor that it undergoes physical or chemical change, but that it prevents cohesion between the water and the plate, and so destroys the emissive power of the plate. Grease may be prevented from entering a boiler by separating it from the exhaust steam or from the condensation water. Where high pressures are used the oil is volatilised, and no exhaust steam separator can remove absolutely all oil from the steam. The emulsified oil contained in the condensation water from high-speed enclosed type engines cannot be separated by any form of mechanical filter. Examination shows that the oily particles are in the form of globules, about $\frac{1}{100000}$th of an inch diameter, and their absolute removal can only be obtained by the use of a coagulant, and subsequent filtration.—**W. Paterson,** *Trans. Jr. Inst. E.*, Meeting held April 3, 1903.

Circulation in Shell Boilers.

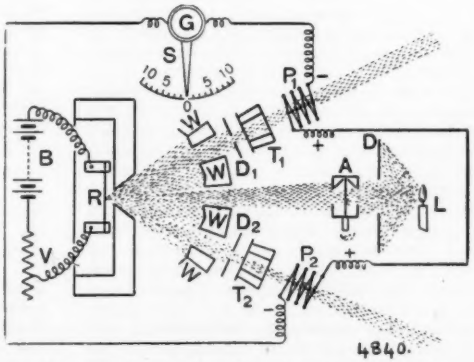
THIS paper deals with the subject on the broadest possible lines, and treats of the circulation of all the fluids connected with the working of shell boilers and with the heat generated. The boiler problem consists in catching as much as possible of the heat generated through the circulation of air among the burning coal as the flame and hot gases pass through the boiler flues, and in transferring as much of it as possible to the inside of the boiler, there to produce other forms of circulation: (1) the circulation of the water in the boiler; and (2) the production of steam, and its circulation from the boiler through pipes to the engine. A very high temperature is produced at the point of combination of oxygen contained in the air with carbon and hydrogen in the coal, and as a result particles of carbon become heated to incandescence; and a large quantity of the energy thus generated is liberated as radiant heat, and gets transferred to water on the other side of the flue-tube plates, there to inaugurate circulation of water and gas within the boiler. The problem is then discussed whether a greater amount of heat can be caused to penetrate a boiler by allowing the flame to play directly on the plate, or by allowing it to produce to some extent an incandescent surface, and thus to liberate some of its energy as radiated heat. Considerable quantities of unconsumed gases in boiler furnace may be readily determined by the Orsat apparatus, which, the author believes, is too little used by engineers in this country, for its constant employment would enable them to determine the most economical degree of circulation of air through the furnaces and flues of boilers. If a much greater quantity of air be circulated through the flues than that necessary to produce complete combustion of the fuel, it is evident that a much larger quantity of the inert gas nitrogen and unnecessary oxygen will be heated up to a high temperature, and the initial temperature of the combustion will thus be lower than it should be, and, as stated before, the heat generated at the lower initial temperature will not pass or circulate in such quantities into the boiler; and as all the air and gases which pass through the flue tubes of the boiler must necessarily be at a lower temperature than would be the case if not much more than the exact quantity of air required for the combustion of the coal be used, it is obvious that a correspondingly less quantity of the total heat will pass into the boiler. An ingenious apparatus is in use in Germany, invented by Arndt, called the "Ados" Automatic CO_2 Recorder. It is said that upwards of four hundred of these instruments are in use in Germany, and about twenty in this country, which automatically take in and analyse the flue gases, and record the results of the analyses in percentages of carbon dioxide by lines of greater or lesser length every few minutes. Flue gases should contain from 13 to 18 per cent. of CO_2, without CO or free hydrogen or hydrocarbons; but the percentage of CO_2 forms a very fair criterion of the velocity of air circulation through the furnace. In many cases the author has found in flue gases not more than 5 or 6 per cent. of CO_2, and in some only $1\frac{1}{2}$ to 2 per cent. For the benefit of those who have not previously worked the Orsat apparatus, the author gives a full description of it in an appendix. If the average proportion of carbon dioxide in the flue gases be known, and the percentage of carbon in the coal and weight of coal burned in a given

time be known, the velocity of the circulation of the air through the flue may be readily calculated; and if the average temperature of the flue gases leaving the boiler be determined, the total loss of heat may be calculated. An apparatus, devised in its original form by Edward Makin, has shown itself capable of greatly increasing both the circulation and combustion of the gases in the flue, also of the circulation of the water in the boiler, and effecting great economy in coal. The apparatus consists of cones, five of which are usually fixed in each flue of a Lancashire boiler behind the firebridge. They are thus set in the flue on the injector principle. A large volume of flame passes through the centres of the cones, and part sweeps round the sides, with the result that all the sides of the cones act as heating surfaces to the water contained. The action of these appliances on the circulation of air through the flue is most remarkable, as the lower strata of unconsumed air are again drawn into the columns of flame passing along the centres. They have the further remarkable effect of increasing the circulation of air generally through the flue. Again, so great is the water circulation produced by these cones that firing may be vigorously carried on when the boiler is filled with cold water, the top and bottom of the boiler becoming simultaneously equally heated.—**William Thomson,** *Trans. Inst. Engin. and Shipbldrs. in Scotland, Vol. XLVI., part 3, Jan. 1903,* pp. 14–34.

LIGHTING, HEATING, and VENTILATION.

A Preliminary Study for a New Standard of Light.

In considering standards of light, it is seen that three distinct types are necessary: (1) the absolute standard: (2) a secondary standard carefully compared with the absolute standard and preserved in a few of the principal laboratories throughout the world: (3) a commercial standard, the accuracy of which will depend on the requirements. A standard of the first type should be both constant and reproducible, whereas standards of the second and third types need not necessarily be reproducible. With regard to the first and third class standards the problem, for the present at least, is satisfactorily solved. The author therefore turns to the second class and considers what are the requirements, and in what manner they may best be fulfilled. By careful regulation an electric lamp may be made to show practically no variation, during, say, one hour, but in the course of a few days the light will steadily diminish. A Hefner lamp will vary slightly from minute to minute, and from day to day, but notwithstanding this, keep for years within a few per cent. of the mean value. For a satisfactory secondary standard both defects must be avoided, and both qualities secured. For the purpose in view the incandescent standard, depending on the constancy of the emissivity of the radiating surface and on the constancy of the temperature at which it is maintained, seems to promise the most satisfactory results. In the choice of a radiating body we are guided by two considerations: (1) it must be capable of withstanding a temperature of at least 1,600 deg. Cent., without fusing or oxidising; (2) its coefficient of emissivity must remain unaltered. Finally, an electric current being the most convenient means of providing the necessary heat, it is desirable that the radiating body should be an electric conductor. Choice is consequently limited almost exclusively to platinum, rhodium, iridium, or their alloys. Leaving for later consideration the final choice between these three metals the author turns to the question of temperature regulation, and concludes that the only choice is to effect regulation by measuring the relative intensity of the radiation of two different wave-lengths. Investigation shows that glass and black fluorspar may be used to analyse the radiation, and the author arrives at the conclusion that "if two thermopiles, one measuring the radiation through glass, the other the radiation through black fluorspar, are connected in opposition, there will be a critical temperature at which the resulting



A PRELIMINARY STUDY FOR A NEW STANDARD OF LIGHT.

galvanometer deflection will be zero. The actual temperature at which this occurs will depend on the relative thickness of the plates and on the relative distances of the thermopiles, but for a given disposition of the apparatus it will be always the same." The disposition of the apparatus arranged in accordance with this conclusion is shown in the diagram here reproduced, and the author believes that there is still a place which can only properly be filled by a light of the type described.—**J. E. Petavel,** *Electrician, April 10, 1903*, pp. 1012–1015.

A Gas Engine Heating Plant.

In a power and hot-water heating plant recently installed by the writer an unique feature is that the hot gases from the gas-engine are used to do a part of the heating of the building, by passing them through a return-tube water heater of the condenser type. This heater is situated at a suitable level so that the return pipes from the hot-water system enter the lower side of the heater, while the flow-pipes rise from the upper side in the usual manner. The amount of heat transferred to the hot-water is controlled by two valves, one leading directly into the chimney from the gas engine, and another attached to the heater. If no heat at all is required in the building, the gases are allowed to escape directly into the chimney. —**W. O. Webber,** *The Engineer (N.Y.), April 15, 1903*, p. 302.

DYNAMOS, MOTORS, Etc.

Three-phase Motors for the Driving of Workshops.

Of the two standard systems, the three-phase and the direct-current, it is largely a matter of opinion as to which will give the best all-round results in any given case. The most strenuous advocates of direct-current working for all classes of work are, as a rule, those whose actual experience in polyphase work is practically nil, while the strongest supporters of three-phase working are apt to lay too much stress on commutator troubles, which may arise with all classes of direct-current machinery. If each case is decided on its merits the three-phase installation will be found preferable, because of its greater simplicity, flexibility, and reliability, it being at the same time cheaper to instal and to maintain. And it appears to greater advantage in these respects as the severity of the work increases. The question of economical speed regulation over a wide range is, however, the weak point of the three-phase motor. The three-phase motor, with permanently short-circuited rotor, is, except with regard to starting performance, an ideal form of motor to employ for all work requiring constant speed. For certain classes of work, in which the motor has to operate in a more or less inflammable atmosphere, it is the only type of electric motor that can be used with absolute safety. However started, this type takes a very large current at starting at a very low power factor, compared with a motor of the slip-ring type. For this reason such motors can in general only be used in small sizes if they have to be started with full-load torque, on account of the effects which the large starting current produces on the pressure regulation of the supply system. Motors of the slip-ring type start with a torque equal to that at full load, with a starting current a little in excess of the full load-running current. Such motors could be specially wound for much greater starting torques; but when the starting torque exceeds twice the full-load torque their running performance is not quite so good. The starting performance of three-phase motors of the slip-ring type, compared with that of direct-current motors, is illustrated in the figure here reproduced. As will be seen, the performance of the three-phase motor is practically as good as that of either of the direct-current motors up to a torque corresponding to that at full load; but at the highest torques the series motor is the most economical of the three, there being, however, but a small difference between the performance of the three-phase motor and that of the shunt-wound motor. In conclusion, the author lays stress on the following points connected with a three-phase installation for power purposes:—(1) The first requirement of the generators used for this class of work is that the pressure regulation should be satisfactory. (2) The power factor of the motors should be as high as possible over a wide range of load. (3) The efficiency curve of the motors over the working range of load should be as flat as possible. (4) A proper starting performance of the motor should be insisted upon.—**A. C. Eborall,** *Jnl. Soc. Arts, April 3, 1903, Vol. LI., No. 2,628*, pp. 464-85.

Speed Control of Electric Motors.

In order to vary the speed of an electric motor, either the excitation or the effective voltage must be varied. With fixed excitation, speed is proportional to voltage at the brushes, and with fixed voltage at the brushes it is inversely proportional to the degree of excitation. Speed cannot, for practical purposes, be reduced by varying excitation from the normal, but it can be increased to an extent dependent upon various conditions. In order to reduce

speed the voltage at the brushes must be reduced. This may be accomplished by the use of resistance coils, or of a motor-generator, and if the amount of reduction of voltage is to be varied, then the motor-generator must have a variable ratio of transformation. The reduction of speed by means of resistance in series with the armature is objectionable, and the method of reducing speed by a motor-generator involves increased first cost, loss of workshop space, and reduction of efficiency. The employment of a shunt motor with rheostat in the shunt circuit gives variable speed without drawbacks, and in this paper the author examines this method, its governing conditions, and the limiting factors to which it is subject. The variable shunt motor possesses a speed variable at will through a limited range, with any desired fineness of gradation from two or three steps to a perfectly smooth and regular gradation from the highest to the lowest speed without loss of efficiency.—**W. B. Sayers,** *Trans. Inst. Eng. and Shpbldrs. (Scotland), March, 1903, Vol. XLVI., Part VI.*, pp. 43-64.

IRON AND STEEL.

Strength of White Iron Castings as Influenced by Heat-Treatment.

HAVING given a résumé of the history of the heat-treatment of white iron castings, the author states some facts regarding the converted metal which results. In early experiments a vast difference was found in white irons, some remaining white and hard after many days' soaking in the annealing furnace, while other specimens yielded readily to the heat-treatment. Analyses of the different samples showed that this difference depended almost entirely upon the presence or absence of silicon. A number of tests on bars have been made giving tensile strengths ranging between 40,000 lbs. and 50,000 lbs. per sq. in., but manufacturers equipped for making converted castings in this way have obtained much higher records. The following analyses before and after annealing, given by Mr. James in the Journal of the Franklin Institute for September, 1900, show that the only change effected by the heat treatment is in the condition of the carbon:

	C.C.	G.C.	Si.	Mn.	S.	F.
Before annealing	2·60	·72	·71	·110	·045	·039
After annealing	·82	2·75	·73	·108	·040	·039

Mr. James states that both silicon and manganese exert great influence upon the carbon during annealing, but the author does not think this to be the case. With regard to chilled cast-iron car-wheels, it seems to the author likely that when the silicon exceeds a certain percentage, the heating action of the brakes may cause annealing of the white iron tread, thus changing the condition of the carbon and causing the chilled tread to become much softer than it would be when the metal contains less silicon. Although it is a misnomer to designate as "steel," castings made from white iron changed to gray iron by heat treatment and subsequently hardened on cutting edges, such castings are very different from true malleable iron castings, or from ordinary gray iron castings. It is much easier to make perfectly white iron castings from metal low in silicon, but such metal is unsuitable for subsequent conversion by heat treatment into gray iron. Some makers of malleable castings now modify their old methods, and practically rely upon heat treatment to anneal their castings, without placing them in oxidising material as formerly to remove the carbon; but such treatment does not and cannot make true malleable iron castings. If the false name "steel" were eliminated a distinct advantage would be gained, for the new metal is worthy of taking a special place in the metallurgical arts, and extended applications of the process may be expected as knowledge of the proper methods of heat treatment and the valuable properties of the metal shall become better known and appreciated.—**A. E. Outerbridge, Jr.,** *Jnl. Franklin Inst., April 1903, Vol. CLV., No. 4*, pp. 289-300.

Magnetic and Electric Properties of Alloys of Iron.

PARTS 1 and 2 of the authors' researches on this subject appeared three years ago. The present part deals with: (*A*) alloys of iron which have been found to be non-magnetic, or nearly so, even in strong magnetic fields; (*B*) alloys of iron, which, within a certain range of magnetic field, have been found to be more magnetic than the purest iron obtainable in commerce. In a note added to the paper, it is stated that experiments with a ring of the aluminium-iron alloy (only recently obtained) did not give such good results as the rod with which the determinations given in the paper were made. It is desirable to draw attention to this fluctuation in the magnetic character of the aluminium alloy, for samples of aluminium with alloy may be placed on the market which may be found not to give the high magnetic quality proved to exist in the particular specimen first tested by the authors. Careful investigation is now being made with a view to the discovery of the cause of this anomaly.—**W. F. Barrett, W. Brown, and R. A. Hadfield,** *Roy. Dub. Soc. Trans., Ser. 2, Vol. 8, 1902*, pp. 1-22.

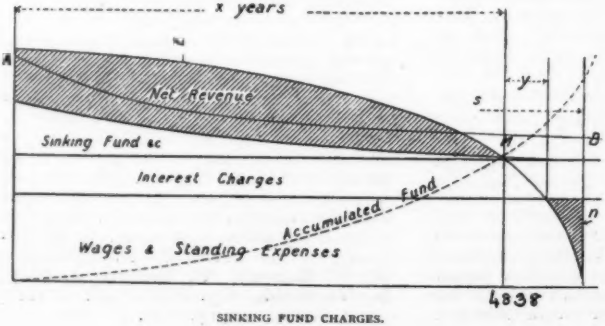
Cast-Iron Wheels to meet the Requirements of the Present Day.

THIS subject is considered by the writer from the standpoint of the relation between the brake-shoe and the cast-iron wheel, and while the design and construction of brake-shoes is fully discussed, practically nothing is said upon the manufacture of modern car-wheels themselves. Observation has convinced the writer that the most desirable metal to use in the brake-shoe is unchilled cast-iron. The efforts of manufacturers have always been directed toward maintaining as much as possible the grinding effect and rolling action between the shoe-face and the wheel, which is only possible with a large proportion of unchilled cast-iron in the shoe-face. It is thought impossible that a hard spot on the face of an ordinary brake-shoe should cut into the tread of a well-made cast-iron wheel, with a good, strong chill where the shoe acts, because the smaller body of the shoe must become more highly heated than the larger volume of the wheel, and hence any hard spot would be destroyed by heat before the chilled metal in the wheel could be cut. Indirectly the brake-shoe may affect a cast-iron wheel to such an extent as to make its removal necessary. The chilled-iron does not absorb or conduct heat readily, and this condition produces the tendency for the wheel to crack. Cracks in chilled iron brake-shoes result in total fracture, and makers have resorted to steel-plate reinforcement to anchor the cast-iron body to the back. The brake-shoe to meet to-day's requirements has a steel back, and is a success regardless of the fact that the extra durability for wear required by railroad officials necessitates the use of iron, which is sure to be cracked under the conditions of modern service. Should a truck be out of square and a wheel be forced against the rail on one side, the flange of the wheel may become highly heated, while the outer tread is comparatively cool. It is this continual change of conditions—first on one side of the wheel and then on the other, aggravated by blows on top and against the side—that causes circumferential cracks, and causes flanges to be broken off. Again, too hard application of the brake checks the motion of the wheel, causing it to slide upon the rail, thus generating intense heat, which destroys the chill and produces cracks. The demands of modern service call for heavier and stronger wheels; but makers are said to be seriously handicapped by the limitations of track conditions and car design. Cast-iron wheels cannot be reinforced in the same manner as the brake-shoe, and makers can only add more weight in the rim and plate, and improve the quality of the metal. The records of tests on cast-iron wheels indicated that the cast-iron wheel of to-day is equal to the increased demand when the braking load is based on the light weight of the car. What will happen with the load based on the total weight of the loaded car is a question yet to be decided. In conclusion, their writer says that the use of a flanged brake-shoe, bearing on the wheel tread and flange, would materially assist the successful operation of the best cast-iron wheel that can be made.—**F. W. Sargent,** *Street Rly. Journ., Vol. XXI., No. 4,* pp. 142–45.

WORKS MANAGEMENT.

Sinking Fund Charges.

IN the accompanying diagram the parallel lines represent interest, wages, and standing charges. Above is the line drawn to represent the usual depreciation. Higher still the main curve starts at a point above total charges, intended to represent expected surplus, and no business should start unless it expects a surplus. Assuming a hypothetical case of a plant worked at its utmost capacity, the upper curve may be taken to represent the earning capacity of the plant in a course of years. Profits are shown by the shaded portion. In *x* years this curve has dropped to the sinking fund level at *M*, and business ceases to pay. The dotted curve represents accumulated funds, and ought to have risen to the height of the depreciation curve before this is crossed by the curve



SINKING FUND CHARGES.

of falling revenue. But the business still pays wages and standing expenses and interest. Interest may be extinguished any time by payment of the principal out of the accumulated sinking fund. This, of course, depends on financial arrangements, or on the relative interest paid for loans and earned by the sinking fund. For a further period of y years the business will run, and may still be run with advantage to the wage-earners and the locality and community in general. But beyond this time, at s years, the shaded portion n represents loss and final bankruptcy. In a permanent trade, of course, prudent management begins to forecast matters after x years, has new works in running order in y years, and has sold the old scrap before much or any of the shaded area n has been developed. Such rigid lines cannot, of course, be laid out in fact, but the underlying principles must be adhered to if continued success is to be secured.—**W. H. Booth,** *Tram. & Rly. Wld., April 9, 1903,* pp. 349-53.

Tools and Gauges in the Modern Shop.

In this paper the author deals more with those features of management and organisation, without which the finest outfit is of little value, than with tools and gauges themselves. It is common talk to hear about labour-saving machines, but too little is heard about labour-saving tools and gauges. Very often, where new plant has been put in, indifferent results only are attained, largely for the reason that there is not a thorough understanding on the part of both masters and men of the vast difference between the tool and gauge equipment in the old and the modern shop. Under the old system results depend mainly on the skill of the man; under the new, on the design, setting, and condition of the tools. To make clear the difference between the old and new tool and gauge outfit, the author gives a series of illustrations contrasting the tools used in ordinary practice under the two methods. Again, the new method requires a new organisation. Separate departments mean new systems of cost-keeping and general management; the apprenticeship question requires modification to suit altered conditions, for the modern apprentice is kept for months at work which is the merest routine, while he needs more opportunity of learning the details of tools and special appliances. But very few engineers have thoroughly equipped and organised tool-rooms; many have none whatever. Even in shops well advanced on the new lines the forge, the anvil, and the hammer are found forming the nucleus of the outfit. That one so often finds the two extremes of dirt and refinement is the best evidence that matters are in a state of transition. With the advent of the new system it becomes necessary to ascertain exactly the dimensions suitable for different classes of work, otherwise the extensive use of modern gauges is not possible. It is not a matter of very great difficulty to establish the limits of accuracy if the task be undertaken systematically. It will repay the effort, for without it cheapness combined with good quality, interchangeability, and uniformity are practically impossible. To reduce outlay in the modern tool and gauge outfit parts must be standardised as much as possible, and the proper storing of tools must be practised. A thorough system of inspection should be established, in which these are the three essentials: (1) inspection of individual parts, (2) inspection of the assembled machine, (3) inspection as to efficient working of the machine. Under the modern system it is necessary to devise methods of rewarding labour which will assist to create and satisfy tool-makers, of whom there is at present a comparatively small supply. On the other hand, there are new conditions to deal with in the machine attendant. His demands must be so satisfied that he will be content to do work that is uninteresting routine and still exert himself to turn out the highest product of which his tools and machines are capable. The premium system best meets the demands of the machine operator, and high day-wages are best for the tool-maker. Improved workshops are the order of the day. If shops remain in such a condition of moisture, temperature, dirt, disorder, and darkness as at present, it will be impossible to keep tools and gauges in good condition or to retain desirable men.—**H. F. L. Orcutt,** *Trans. Inst. Eng. & Shipbldrs., Scotland, April,* 1903, *Vol. XLVI., Part 7,* pp. 1-17.

Gift Propositions for Paying Workmen.

How to change the worker's attitude toward his work by means of a change in the system of apportioning the recompense for it would seem to be the foremost problem of the opening years of the century. How shall the worker, whatever his grade of skill or efficiency, who has hitherto worked only for a fixed daily wage, be so paid hereafter that he shall not only get all that he earns, but that he shall be willing and even desirous to do more, and thus to earn more, up to the limit of his ability? On the face of it piecework, or pay exactly proportioned to the amount of work done, is the only exact justice. Unfortunately, it is sometimes so

craftily manipulated that justice deserts it. On the promise of equitable payment for actual work, and in exact proportion to what is done, the worker comes too often to find that in the end it is a mere arrangement to squeeze from him more work for less wages, so that if by day wages some are paid too little, by piece-work a much greater number are ultimately so paid. Too many bosses get alarmed as soon as the men by piece-work begin to get any appreciable percentage above day wages, and then the cutting of prices begins, and the men soon get disgusted. It is my view that for everything a workman can do there is a fair and equitable price, whatever the difficulty of determining that price, and that when the man does the work he should get the price. The piece which by extra exertion he does last brings as much or more profit to the proprietor as the first piece that is done, and it does not appear why the man should not have his pay the same for each. No one can assert that the premium plan gives him this. It does not appear to me that the premium plan, or any other *gift* proposition, offers or suggests a permanent or satisfactory solution of the problem of equitably adjusting the wage to the work, so that the opening century still has a job before it to devise some scheme more equitable and more deserving of permanent adoption. — **F. Richards,** *Paper presented at the Proc. Am. Soc. Mech. E., Dec. 1902, Vol. xxiv.*

MECHANICAL.

Layout of Corliss Valve Gears.

THIS is the first article of a series on this subject, and the immediate object is to give a method of laying out a Corliss or other similar valve gear, using as a starting-point the desired percentages of compression and release. The method at present in use does not involve these quantities, but is based on empirical tables of "laps." The basis of the method is due to Prof. John H. Barr, of Cornell University.—**Sanford A. Moss,** *Am. Machnst., April 25, 1903,* pp. 518–22.

METALLURGY.

Blast-Furnace Practice.

THE diagram given includes data from British and American furnace records, and will be found both useful and interesting to all engaged in the design and working of blast furnaces. The left-hand column gives coke consumption per day of 24 hours per furnace where the blast is heated in fire-brick stoves, while the right-hand columns show the volume of blast per minute to be supplied by the blowing engines and the horse-power of the air cylinder. The diagonal line indicates the pressure of the blast due to the volume. Some modifications are necessary in the results shown in the diagram under certain conditions. For instance, the volume of air required will be affected if the coke has a higher carbon content than 85 per cent.; the volume of blast must be increased where the friction in air-ducts is great. With furnaces of large capacity and low-blast pressure the reduction of pressure in the furnace is very great, while in the case of large output compared with capacity the effective pressure of the blast is maintained much higher in proportion. The diagram clearly shows that the consumption of coke, and, of course, the output of pig-iron, cannot be increased by raising the pressure of the blast unless the volume is increased proportionately. The chief use of the diagram is its application for comparing the statements of furnace working by furnace managers. It will be found to indicate that at many British furnaces the output would be considerably increased simply by increasing the volume of blast and without increasing the pressure to any extent, while in other cases the increased output could not be obtained unless the pressure as well as the volume were increased.—**Horace Allen,** *Iron and Coal Rev., Feb. 20, 1903,* p. 487.

ERRATA.

Page 477.—Inscription under Fig. 9: For *Prezometric* read *Piezometric.*

Page 481.—Twelfth line: For 60 read 60^2.

Page 482.—Second column in table: For *special* read *specific.* Third column in table: For $M2 \times 105$ read $M^2 \times H10^5$.

Page 488.—Tenth line: For *suburban district* read *suburban track.*

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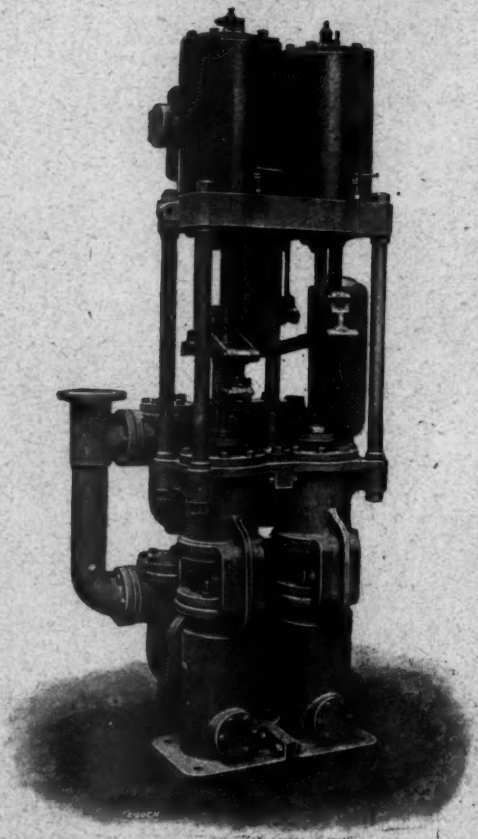

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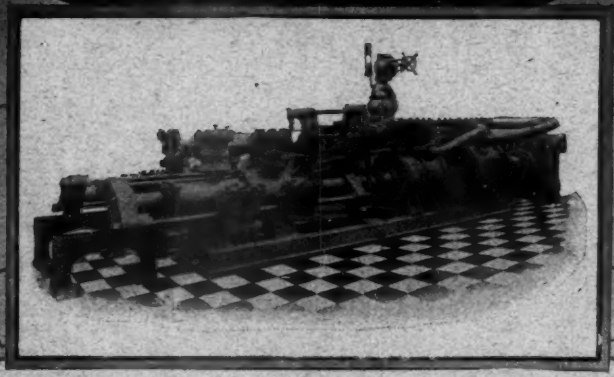

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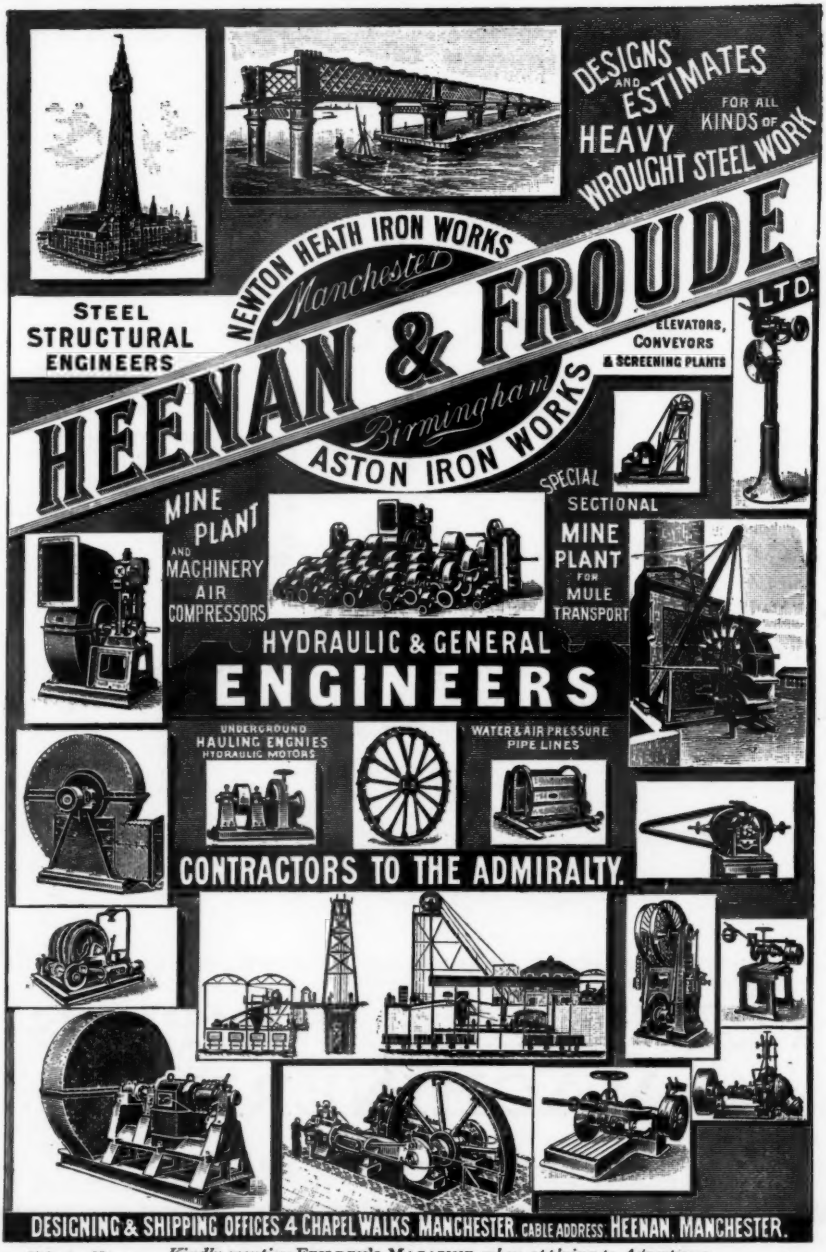
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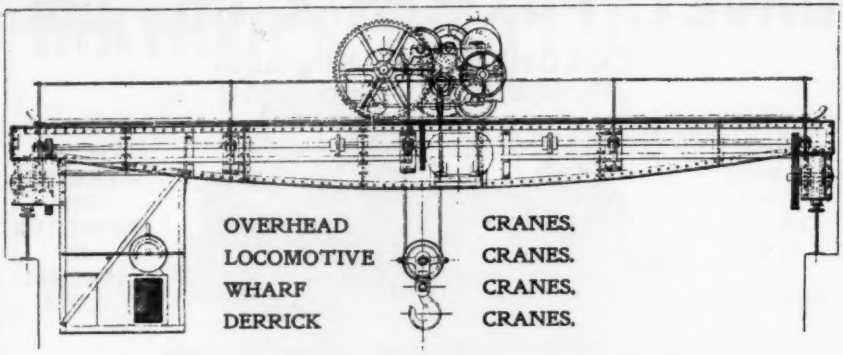

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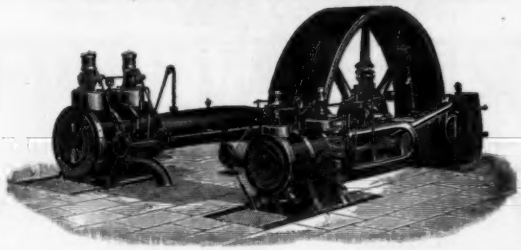

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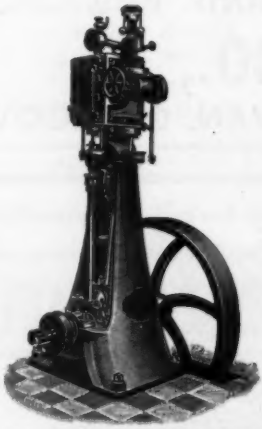

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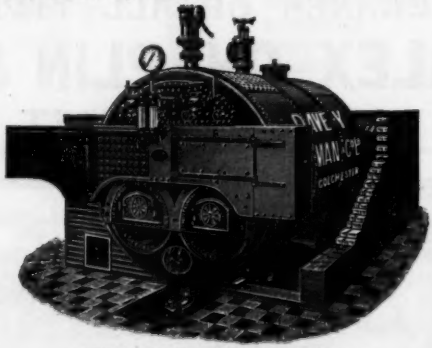

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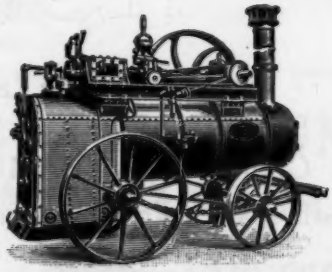

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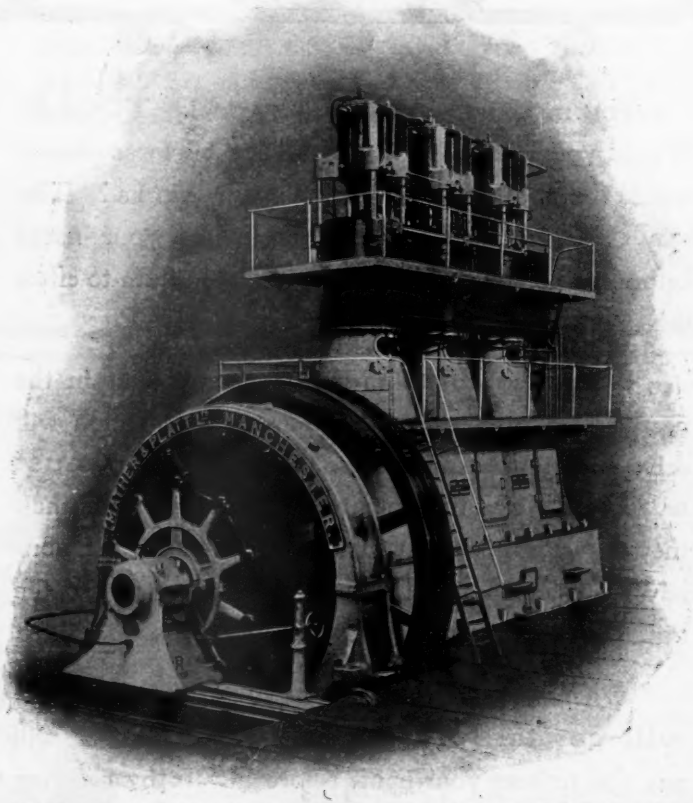

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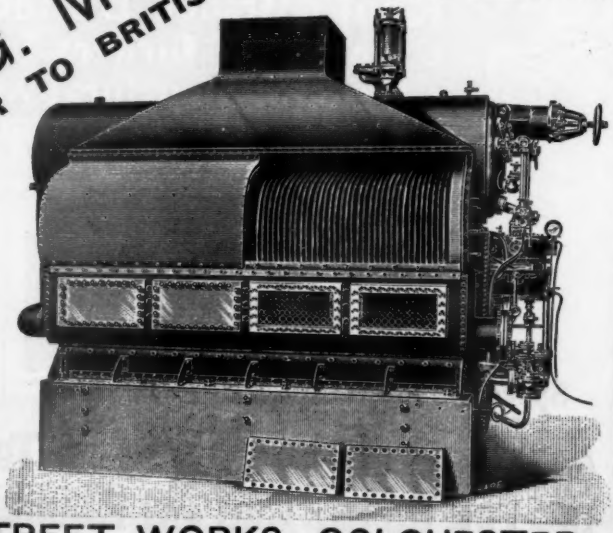

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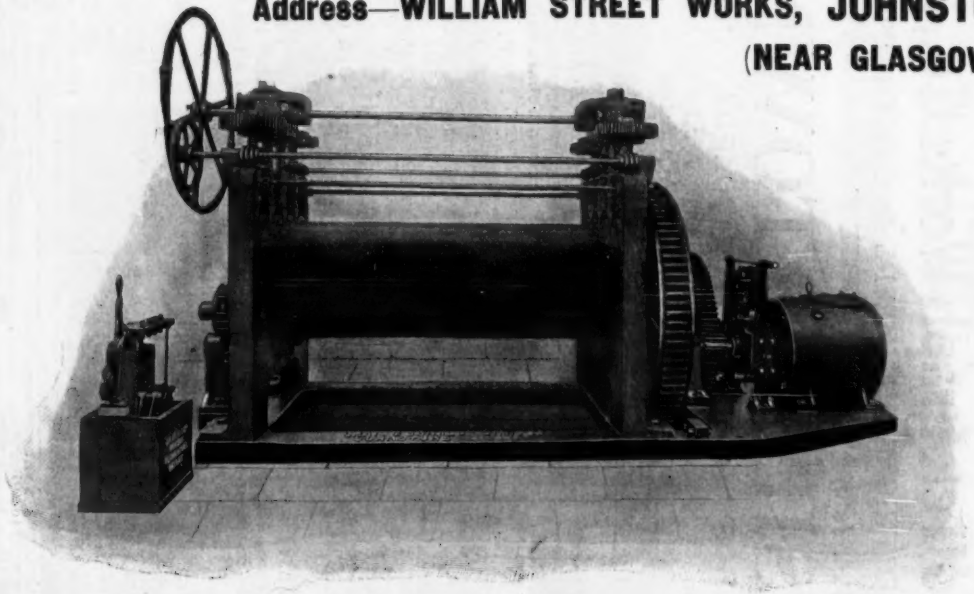

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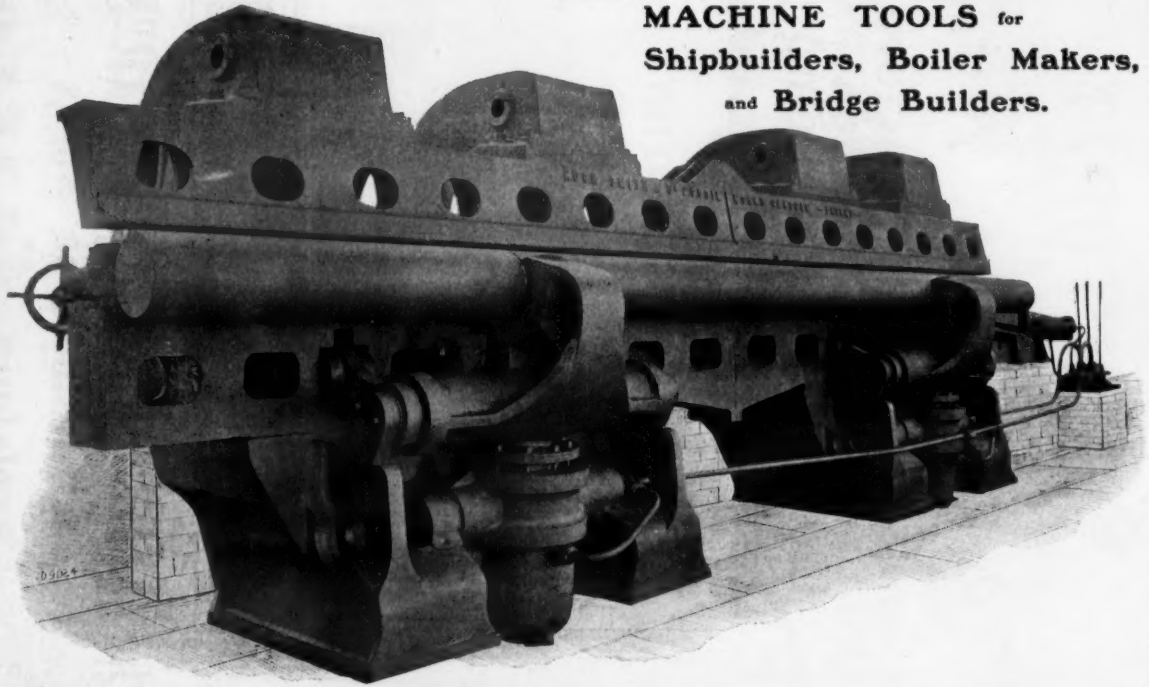

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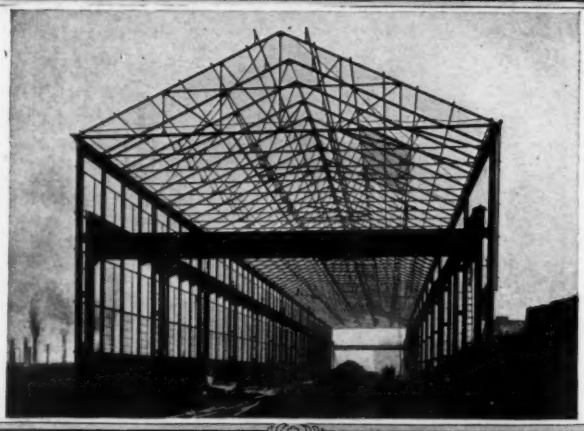

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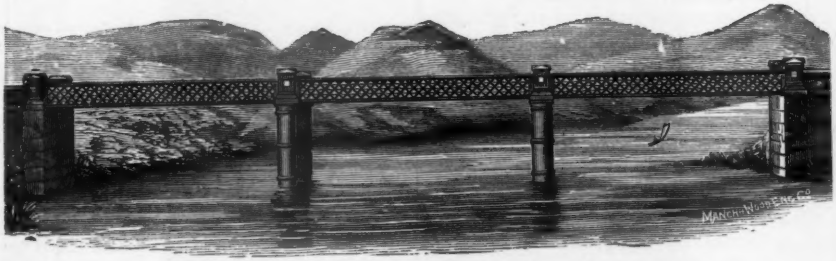

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BOOKS RECEIVED.

CONTINUOUS-CURRENT DYNAMOS AND MOTORS AND THEIR CONTROL. By W. R. Kelsey, B.Sc., A.I.E.E., F.Ph.S. London: The Technical Publishing Co., Ltd., 55, Chancery Lane, W.C.; and John Heywood, 29, Shoe Lane, E.C. Price 5s. net.

SPECIFICATION for a Lancashire Boiler and Boiler Seating. By "Inspector," M.I.M.E. Manchester: The Technical Publishing Co., Ltd., and John Heywood.

L'ELECTRICITE A L'EXPOSITION DE 1900. Published under the direction of E. Hospitalier and J.-A. Montpelier. Paris: Vve. Ch. Dunod, 49, Quai des Grands-Augustins. 1903.

IRON AND STEEL, IRON ORE, AND COAL STATISTICS for the United States, Great Britain, Germany, France, and Belgium. Revised to the end of 1901. By James M. Swank, General Manager of the American Iron and Steel Association, Philadelphia. 1903.

CATALOGUES RECEIVED.

SIMPLEX STEEL CONDUIT CO., LTD., Coventry Street, Birmingham. This is the fifth annual price list issued by this firm in connection with the Simplex Steel Conduit System, and it contains a notice to the effect that on account of the increased demand for Simplex material, it has been found necessary to extend the Birmingham works, and to equip new shops for the manufacture of iron-cased distributing boards and special fittings. A new feature referred to in this catalogue is a complete sand-blasting plant, through which process all Simplex fittings now go previous to galvanising or enamelling.

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GRAHAM MORTON & CO., LTD., Leeds. An exhaustive catalogue of the conveying, screening, and crushing plants for collieries, mines, boiler houses, gas and electric light works, etc., undertaken by this firm.

THE FAIRBANKS CO., 78-80, City Road, London, E.C. A catalogue of their reed pipe fitters' tools, all of which are particularly useful for pipe and tube fitters, being the results of extensive experience by the makers of tools of this description.

THE BRITISH PROMETHEUS CO., LTD., 18, London Road, Kingston-on-Thames. A catalogue of this company's system of heating and cooking by electricity. The principal objections that have been urged against the use of electricity for cooking and heating purposes have been done away with by the invention of the "Prometheus" System, and the reduction in cost of electrical energy (for cooking and heating apparatus), that has recently taken place in most of the large cities and towns.

LIERNUR'S ENGLISH SYNDICATE, LTD., Cannon Street House, 110, Cannon Street, E.C. A descriptive account of the Liernur Improved Pneumatic Sewerage System, as installed at Stansted, Essex.

COMMERCIAL INTELLIGENCE CONVERSION TABLES for Foreign Moneys and Measures. Part I.—English-French, English-German Tables. London: The Commercial Intelligence Publishing Co., Ltd., Temple House, E.C. Price 2s. net. This is a reproduction in book-form of a long series of tables of commercial equivalents to assist in the ready preparation of foreign price lists, published during the past few years by "Commercial Intelligence."

THE BRITISH SCHUCKERT ELECTRIC CO., LTD., Clun House, Surrey Street, W.C. An illustrated pamphlet of this firm's continuous-current generators.

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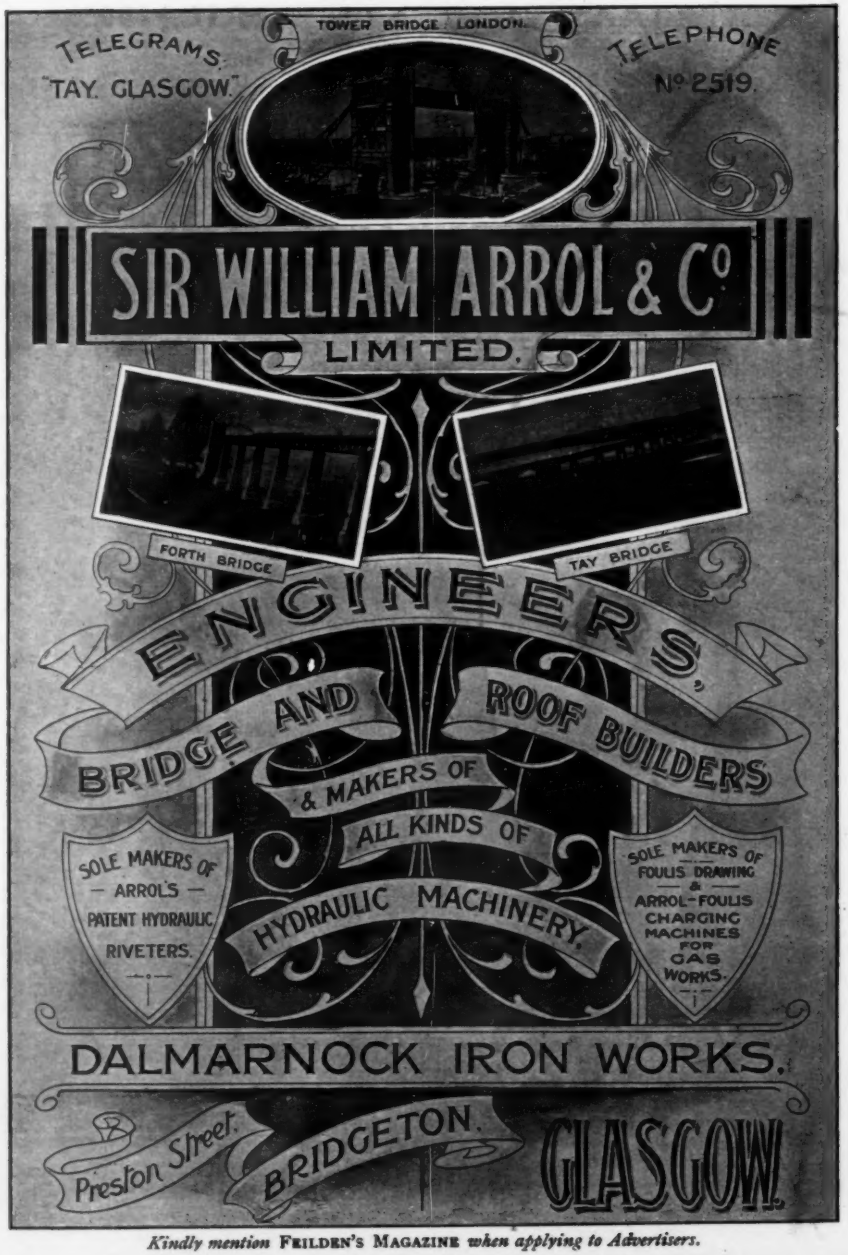
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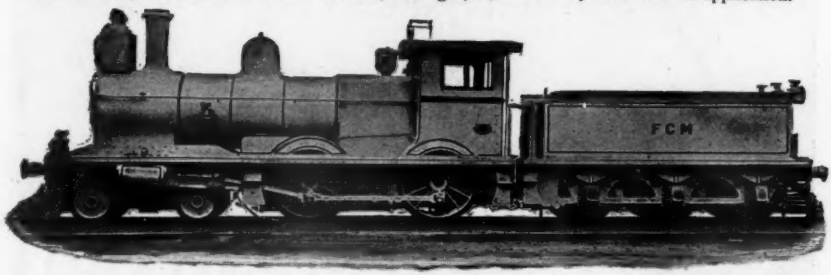

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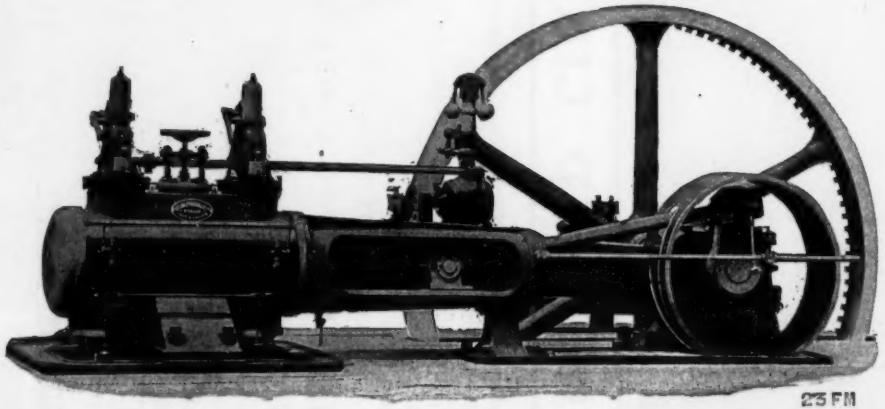

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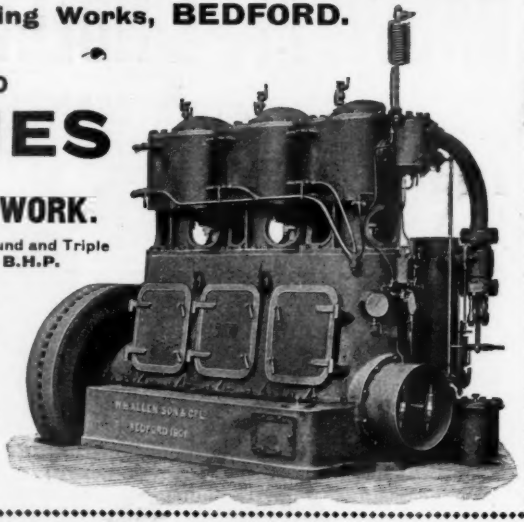

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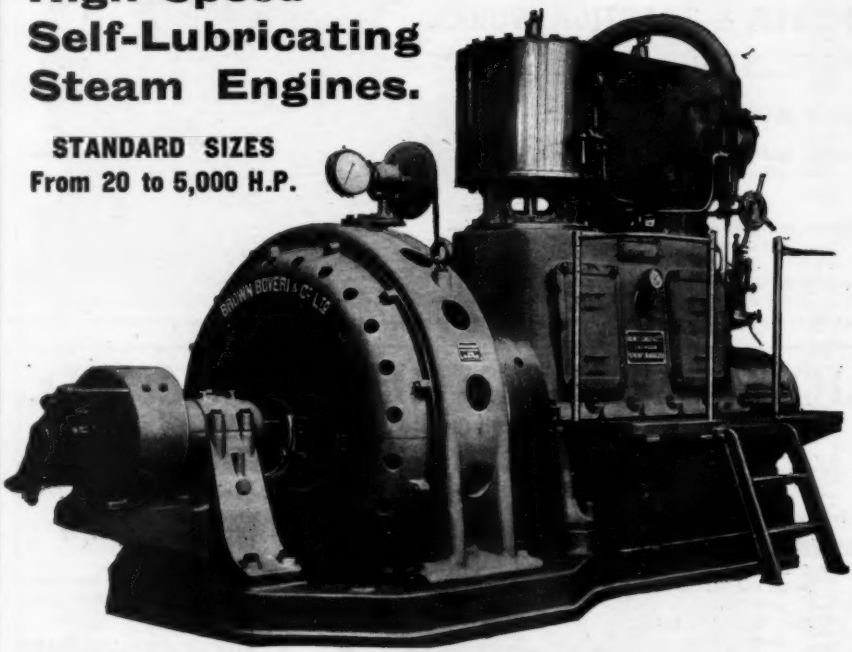

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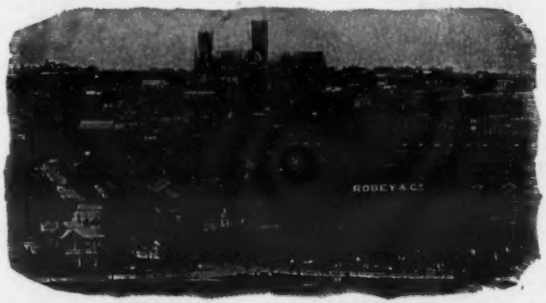

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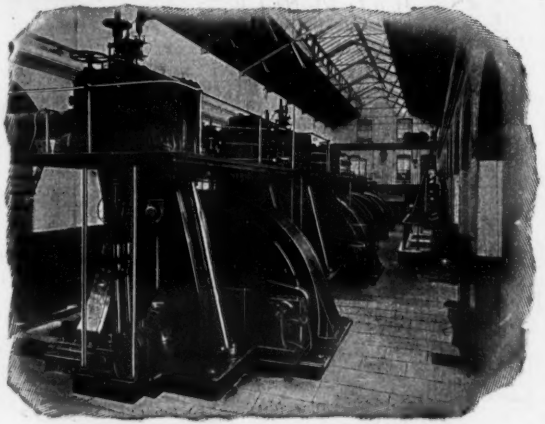

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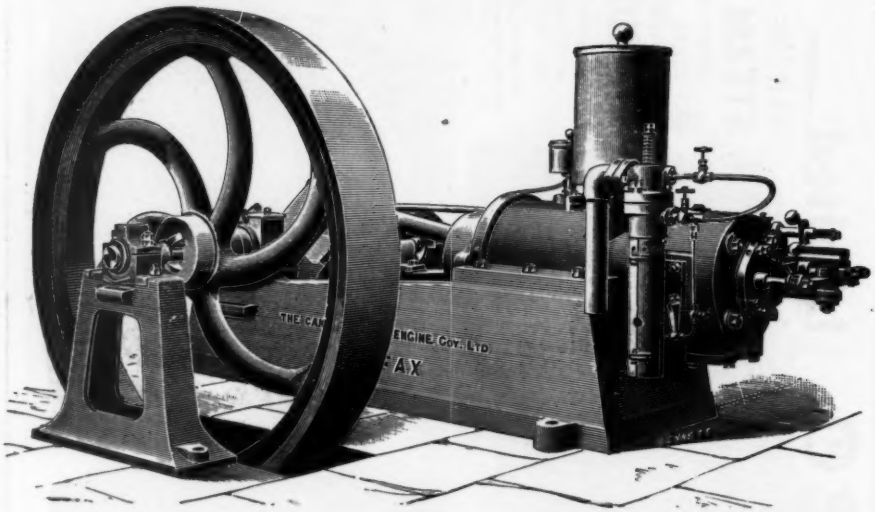

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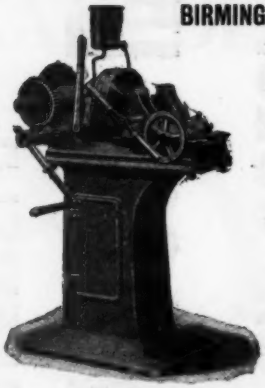

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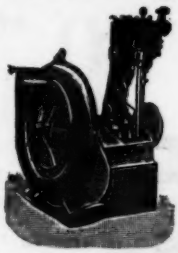

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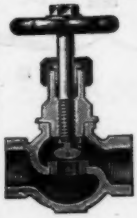

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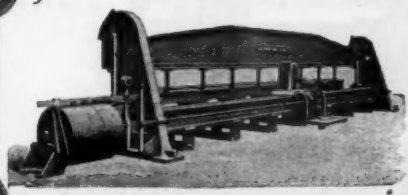

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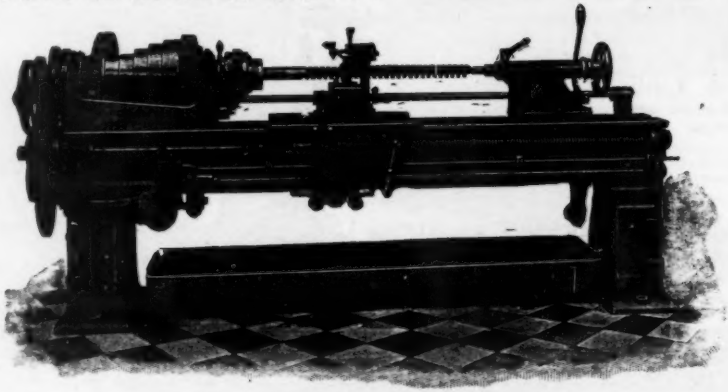

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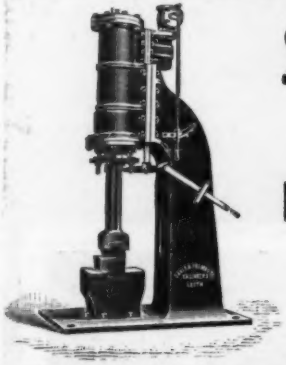

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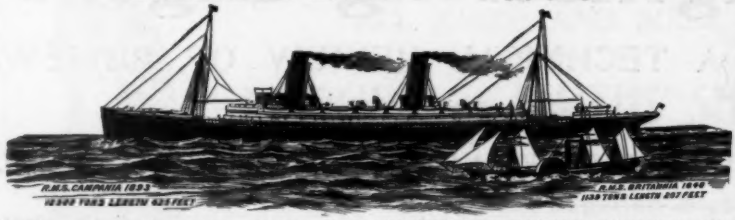

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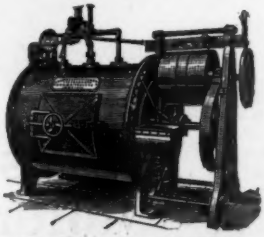

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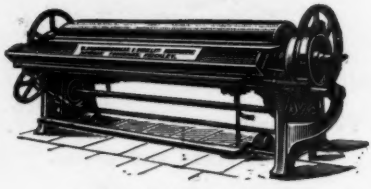

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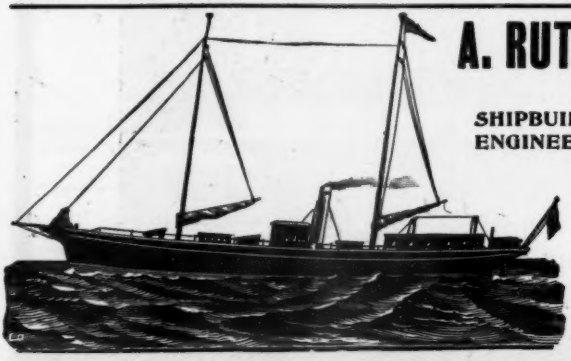

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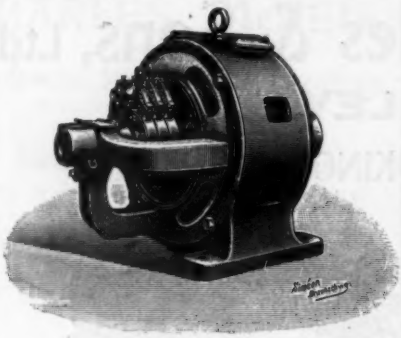

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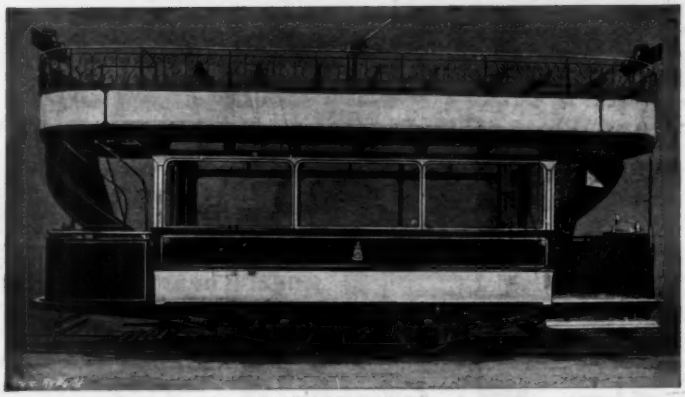

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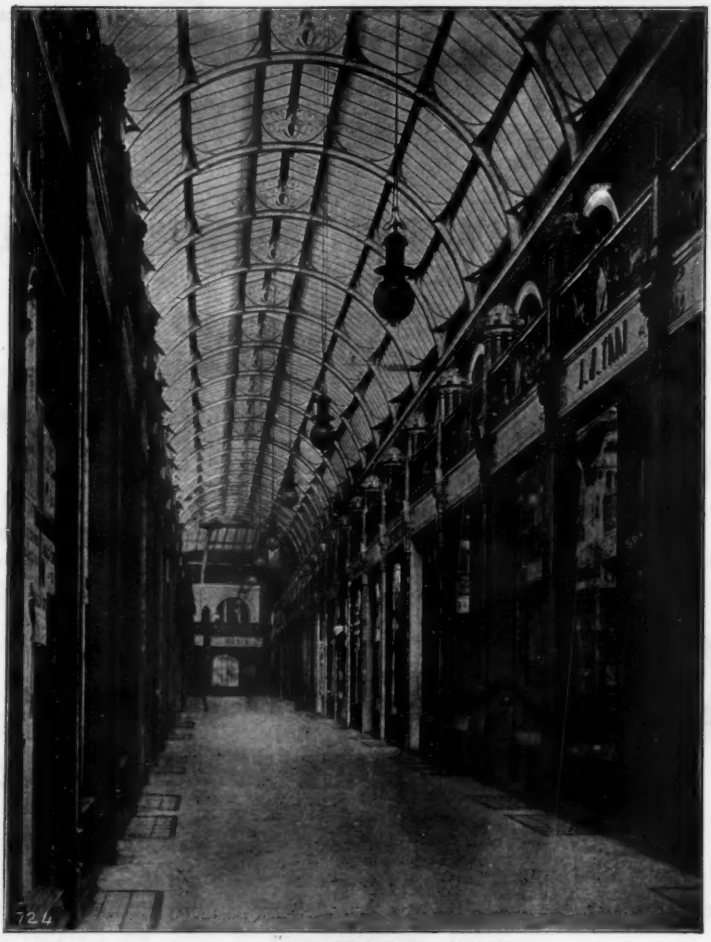

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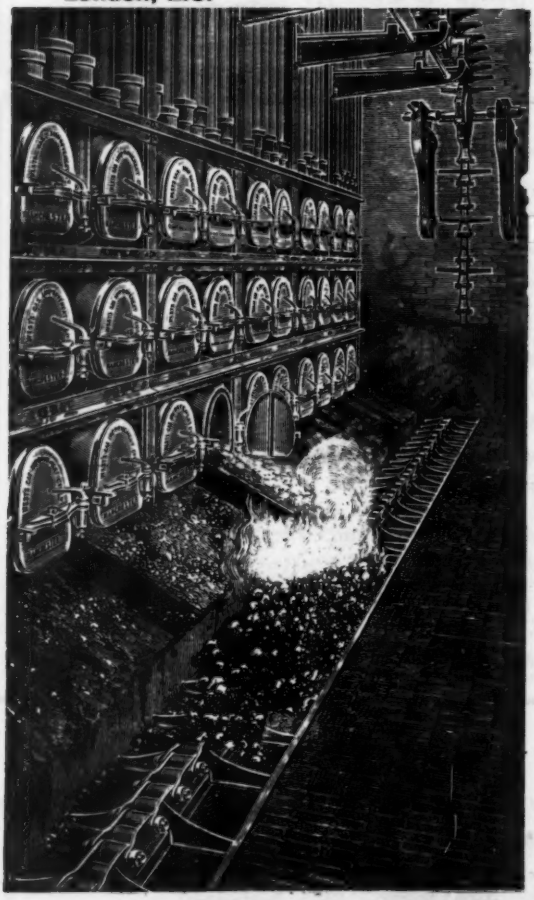

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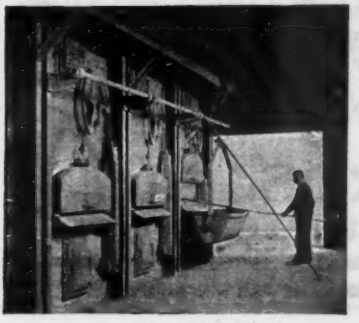

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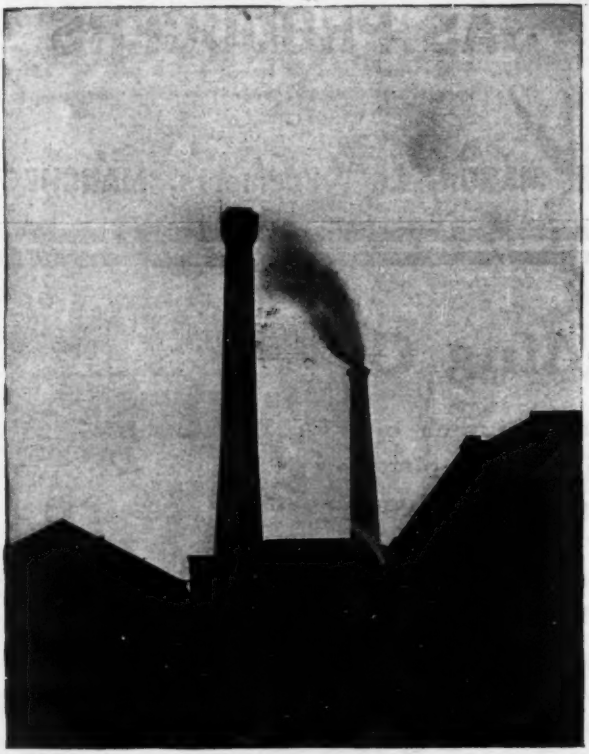

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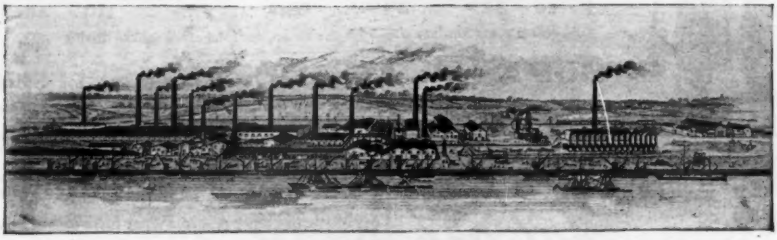

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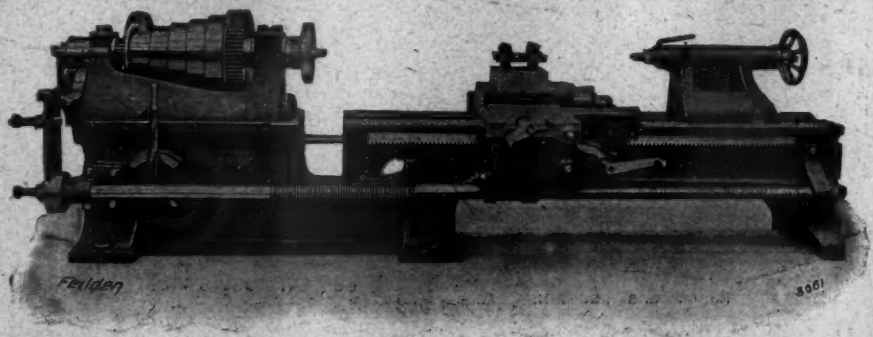

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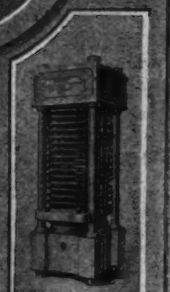

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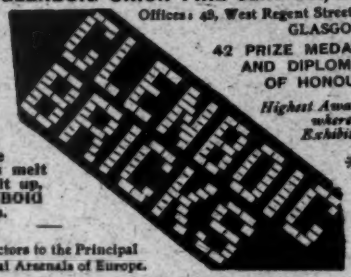

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